Hemenway Southwestern Expedition

HOPI SONGS

BENJAMIN IVES GILMAN

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BY

BENJAMIN IVES GILMAN
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TO THE MEMORY OF

Mrs. Mary Hemenway

HONORED WHEREVER THE STUDY OF ARCHÆOLOGY IS PURSUED
THIS TARDY FRUIT OF AN INQUIRY
BEGUN AT HER INSTANCE, WITH HER AID
AND UNDER THE STIMULUS OF HER ENTHUSIASM
IS INSCRIBED
WITH GRATITUDE AND RESPECT

THE study of Hopi, or Moqui, singing, to which this volume is devoted, completes an inquiry into Pueblo music begun in 1891 with a study of Zuñi Melodies.[1] The records upon which both investigations have been based were obtained in Arizona by Dr. J. Walter Fewkes, now of the Bureau of Ethnology, Washington, at the time in charge

[1] Published in vol. i of *A Journal of American Archæology and Ethnology*, Boston, 1891. Review by C. Stumpf in the *Vierteljahrsschrift für Musikwissenschaft*, 1892, Heft 1, under the title, "Phonographirte Indianermelodien." Among the chief sources of information regarding aboriginal American music are the following: Theodore Baker, *Die Musik der nordamerikanischen Wilden* (Leipzig, 1882); C. Stumpf, "Lieder der Bellakula Indianer (*Vierteljahrsschrift für Musikwissenschaft*, 1886, Heft 4); Franz Boas, "The Central Esquimo" (*Bureau of Ethnology, 6th Annual Report*, 1888); Miss Alice C. Fletcher, "A Study of Omaha Indian Music," with a report on the structural peculiarities of the music by J. C. Fillmore (*Archæological and Ethnological Papers of the Peabody Museum*, i, 5, Cambridge, Mass., 1893); Franz Boas, "The Kwakiutl Indians" (*United States National Museum, Report for 1895*); Miss Alice C. Fletcher, "The Hako: A Pawnee Ceremony" (*Bureau of American Ethnology, 22d Report*, Part 2, Washington, 1903); O. Abraham and E. M. von Hornbostel, "Phonographirte Indianermelodien aus British Columbia" (*Boas Memorial Volume*, New York, 1906); Natalie Curtis, *The Indian's Book*, New York, 1907.

The Hopi and other Pueblo tribes of the southwestern United States are the subject of papers contributed by J. Walter Fewkes, J. G. Owen, F. H. Cushing, A. F. Bandelier, H. F. C. ten Kate, V. Mindeleff, G. A. Dorsey, H. R. Voth, and others to the *Journal of American Archæology and Ethnology*, issued under Dr. Fewkes's editorship, 1891–94, to the *American Anthropologist*, and the *Journal of American Folk-Lore*, and to the publications of the Bureau of American Ethnology, the Smithsonian Institution, the National Museum, the Field Museum (Anthropological Series), and the Archæological Institute of America (American Series), as well as to other publications mentioned in the bibliographical list at the close of this volume. Many of these papers are abundantly illustrated. The reproductions of photographs in the "Study of Pueblo Architecture" contributed by V. Mindeleff to the Eighth Annual Report of the Bureau of Ethnology, 1886–87, show the country and the villages of the Hopi; and those in the papers of G. A. Dorsey and H. R. Voth of the Field Museum, the people themselves and their ceremonial life. Vol. iii of this series contains striking illustrations of the kiva ceremonies of the Snake and Antelope Fraternities at the Pueblo of Oraibe, and describes the singing of the eight traditional songs, of which the present notations give six from the corresponding ceremonial at the Pueblo of Walpi, as the most beautiful incident

of the Hemenway Southwestern Expedition, who first applied the phonograph to the preservation and study of aboriginal folk-lore.[1] All of the present series were taken at the Pueblo of Walpi, on the East Mesa, the singer of Çoyóhim-katcina coming from Oraibe, on the West Mesa, one of the more primitive of the seven Hopi villages. All of the songs but the last appear to have a religious or mythological significance, the first six being among those sung in chorus by a number of priests in an underground chamber, or kiva, in the course of the well-known Snake ceremonial. The word katcina denotes a kind of mediating spirit. The name of the last song, "Mana," means maiden, and the song is sung by a man accompanying a dance of girls. A rudimentary flute appears to be the only one of several instruments used by the Hopi to accompany their singing, which is not almost wholly a source of noise. Specimens show holes at one, two, three, three and a half, and four sevenths of the length, making possible a sequence of a very roughly approximate octave, fifth, and equally divided fourth. The instrument gives its name to an important ceremonial, and is apt to be used, according to accounts, without close relation to the melody sung, as its make would suggest.

The accompanying notations aim chiefly to present a close approximation to the actual course of tone produced by the singer. The measure of this music is often exceedingly difficult to observe, sometimes sounding differently at will, and the notations are in this respect undoubtedly less accurate than in the matter of intonation. To the singers themselves time and emphasis perhaps altogether outweighed the element of interval. Tolstoi writes that in a peasant's song the motive appears "an accessory, coming of itself without effort, and seeming solely to mark the cadence."[2] As an art of tone, Pueblo singing is doubtless subliminal in the same way.

This probability has been kept in mind throughout the study of the

of the occasion. The *Handbook of American Indians*, published by the Bureau of American Ethnology (Part I, Washington, 1907), is an encyclopædia of its subject. Other books are: *The Snake Dance of the Moquis of Arizona*, Capt. J. G. Bourke, U. S. A. (New York, 1884); *Zuñi Folk Tales*, F. H. Cushing (New York, 1901); *The Delight Makers* (a romance), A. F. Bandelier (New York, 1890); and *The Song of the Ancient People*, Edna Dean Proctor, with an introduction by John Fiske and a commentary by F. H. Cushing (Boston, 1893).

[1] "Contribution to Pasamaquoddy Folk-Lore," *Journal of American Folk-Lore*, October–December, 1890.

[2] *La Guerre et la Paix*, vol. ii, p. 110.

songs. To do justice to this music without overdoing has not been easy. The wiles of the heavenly maid are well known to all her pursuers. Analogies and rhythms and coincidences and laws throng every step of the student of music, delighting and bewildering him by their beauty and profusion. All are true, perhaps, and none as they appear. He is wise and well-balanced indeed who can preserve perfect sobriety of judgment. Most of what is claimed for the present songs will, it is believed, be found simply a way of describing the facts of the notations; and the residue of interpretation infers not to a conscious but instinctive purpose.

The science of music, although ancient, counts few votaries. The reason is plain. Essentially fugitive, music must in the main be studied indirectly, through a difficult and always imperfect symbolism that tends to reduce the most passionate form of artistic expression to a datum for abstract inquiry. "Musical works," wrote von Winterfeld,[1] "do not readily offer themselves to investigation, as do the works of the material arts. They must be recalled to life out of dead signs, and is their imaginative contemplation insufficient, performers must be gathered and trained in order to obtain the actual impression of sense. For this reason most investigators have devoted themselves to the inquiry into musical theory."

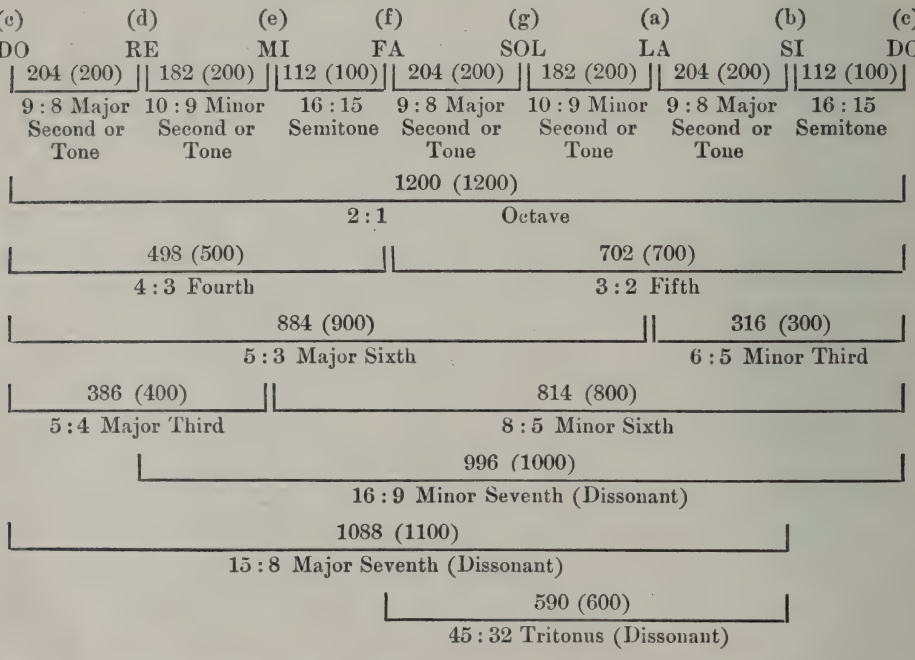
Through the invention of the phonograph the actual impression of sense is henceforth in a measure open to exact — if still exacting — investigation. The study of performance attempted for the Zuñis has since been taken up for many other non-European peoples. The field is a wide one, the harvest will be of value not alone to musical science, and those who aid should no longer be few.

CAMBRIDGE, MASS.,
July, 1908.

[1] J. Gabrieli, 1834, vol. i, p. 63.

TERMS AND SIGNS

In the following table of the diatonic scale and intervals, the breadth of the latter, both pure and tempered, is expressed in hundredths of a tempered (piano) semitone, the tempered in parentheses. This is the unit of interval measurement proposed by A. J. Ellis, and called by him the cent. The ratios are those of the vibration numbers of the component tones of the pure intervals.



The word *trichord* is hereafter used by analogy with tetrachord, to signify a combination of three notes spanning the interval of a fourth or less: and the word *tetrad* by analogy with triad, to signify a combination of four notes spanning the interval of a fifth or more. A trichord or triad is called major or minor according as the lower interval is the larger or the smaller. The extremes of these combinations are called *summit* and *base*, the intermediate note or notes, the *axis* or *mediants*.

Following the analogy of the compass, the black keys of pianos are denoted by combining the letters for the white notes between which they lie: thus, cd for the black key representing c♯ or d♭.

The sign + or — after a letter, or combination, signifying a certain pitch, denotes a pitch slightly above or slightly below.

The symbolism of the notations is more fully explained on pp. 53 f.

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THE ROTE-SONG OF THE HOPI

I

THE ROTE-SONG OF THE HOPI

1. *The music of America*

In my paper on Zuñi Melodies I called them examples of a music without scale.[1] The view was a novel one, and its confirmation has been sought in the performances of Hopi singers here presented. These supplement the previous negative result by indicating methods of composition and performance which replace and exclude reliance upon a scale. They strengthen the belief that aboriginal American music is a type apart, whose essential remoteness from the music of Europe and Asia may be symbolized, as it doubtless was conditioned, by the physical isolation of the Americas.

A new artistic principle, ethnic in scope, demands a name. The old word "rote-song" (route) signifies, by the analogy of a pathway, the pursuit of a beaten track of tone, and is here taken to imply the substitution of melodic autonomy for the support and limitation compared in the word "scale" to a stairway.

2. *Scale; and music with or without it*

Defining music as the fine art of interval, a scale is an interval-order auxiliary in its production. What is an order of intervals, and how may it be operative in their satisfactory combination?

An order of intervals is a complex relation in tone. Tones differ from noises, the other species of auditory sensation, in presenting themselves arranged in a continuous series, having one dimension, called

[1] Page 89. "What we have in these melodies is the musical growths out of which scales are elaborated, and not compositions undertaken in conformity to norms of interval order already fixed in the consciousness of the singers. In this archaic stage of the art, scales are not formed but forming."

height or depth. The elements of the series are individual tones, and musical intervals are relations between these. Such relations may be conceived as themselves having relations in tone, combining intervals into orders. Excluding the limiting relation of identity or unison, an interval order may be defined as a set of intervals in which one of the tones, a or b, forming one of the set, forms with a tone c, different from either a or b, a second of the set in a certain sense; and one of these three different tones forms with a tone d, different from either a, b, or c, a third of the set in a certain sense: and so on until the set is exhausted.

The different tones conceived as the elements of an interval-order are known as the steps of the order. A step may be defined as a tone conceived as related to every one of a certain number of others, either directly by one of a certain set of intervals in a certain sense, or indirectly through others of the tones and by a certain sequence from the intervals, each in a certain sense.

It is through the conception of its steps that an interval-order becomes operative in interval combination. The viewing of notes as steps is the differentia of scalar music. A scale is a complex relation in tone with one or other element of which each note of certain music is identified by the maker.

In European music the names of the notes — a, b, c, do, re, mi — designate steps in one order of intervals called the diatonic scale. Every note of a European composition either has its diatonic name or is regarded as an accidental, the consciousness of scale being the invariable concomitant of musical production. The names of the accidentals also give them a place in the scale-system as new loci resulting from a changed conception of the step represented by a given tone, — or, as it is called, modulation from one key to another. Scale is even so familiar a fact as to be difficult to grasp. We fancy that music without it would hardly be music. Yet if the consciousness of scale be simply the embedding of each actual note in the same fancied complex of related notes, its presence is not essential to the combination of intervals into a work of art. Taking away the scale-consciousness takes away a norm

through which different compositions receive structural likeness, but does not destroy their identity. They become individual but may remain each a norm to itself. Their irregularity may have the precise outlines of arrested waves.

3. *Pueblo music sounds independent of scale*

Pueblo songs produce this impression. What seems at first a lawless cacophony, at least in the phonograph, proves on further hearing to consist of phrases repeated with an exactness surprising to the European ear in view of their divergence from diatonic norms. The singer's musical consciousness seems restricted to a few intervals of simplest vibration ratio approximately rendered, and to melodic sequences formed by their various analysis and synthesis and rendered with a certain loose fidelity. If a scale were in his mind, even dimly, it should make itself known both in a more uniform interval production and in a more impartial use of the tones continually at hand in the fancy. The hearer seems witness to a wholly strange method of musical thought and delivery. The total complex of tone, timbre, and articulation — doubtless at the time movements, and other noises also — moves on apparently without guidance by any vanguard of fancied tones at fixed intervals. Upon reflection the surprise occasioned by the security of its movement appears uncalled for. A good mimic reproduces by an act of unaided memory and with indistinguishable accuracy very delicate *nuances* in the long sequence of tone and noise constituting his model's delivery. Why may not this music be perpetuated as a vernacular is, by the imitation of specific examples and not the application of general standards? It is true that such standards exist in the European music which these Pueblo tribes have for centuries had opportunities to hear. Yet the sacred rites of which much of this singing forms a part seem exempt from European influence: and their element of tone is presumably no less aboriginal.

4. *Four corroborative arguments*

The real bar to the belief that Pueblo musicians know nothing of scale is the diatonic form of their music itself.

On formal analysis the following appear the logical rights and duties of the two sides to the question: —

For scale. The coincidence of any music with the diatonic order of intervals is *prima facie* evidence that that order is the scale of the music; but the evidence is not complete without an explanation of its divergences therefrom. These may be accounted for in two opposite ways: either as inaccuracies of execution or complexities of conception. The musician may rudely grasp (or roughly deliver) the diatonic step he proposes; or he may change it by an accidental; or view it as a new step in uttering it, that is, go on in a new key.

Against scale. Any opposing theory of a music showing diatonic features must both explain its coincidences with diatonic form and show the insufficiency of mistake, alteration, and transposition to account for its divergences therefrom. The coincidences will be accounted for if proved characteristic of harmonic sequences, or the contribution of the observer. The divergences will be proved not to be mistakes if repeated by the same or different singers; and not to be accidentals or due to modulation if they imply complex changes of the pitch or conception of notes.

The evidence of the present notations bears strongly against the diatonic theory of this music on all four of these points. A measure of coincidence with the diatonic scale is implied in a predominant use of approximations to intervals of simplest ratio such as the phonograph here records. The diatonic form of the notations by ear proves in part the invention of the observer. The divergences of the songs from diatonic norms are in many cases shown to be intentional by repetition. In many cases also their explanation by the shifting of notes or of key demands an improbably complex use of the scale.

(a) *Melody of simple ratios the parent of the scale*

A measure of coincidence with the diatonic scale is implied in the predominant use of approximations to consonant intervals in melody.

Any sequence of the seven consonant intervals, minor third, major third, fourth, fifth, minor sixth, major sixth, and octave, tends to move within, and hence to outline the diatonic scale. There are seven

steps in the diatonic scale; and of the fourteen possible movements by these intervals down and up from each, ninety-eight in all, sixty-six, or two thirds, will end on other steps of the diatonic scale extended in octaves. If the thirds and sixths employed are subject to the quarter tone aberration common in Pueblo music, the number will be ninety-four, or nineteen twentieths. The diatonic form, either with or without occasional lapses, is the necessary dress of any harmonic melody. In this physico-mathematical fact plainly lies the genesis of the diatonic scale. To argue therefrom to a diatonic consciousness is to mistake cause for effect, the root of the diatonic order for its fruit.

(b) *The European ear hears diatonically*

The diatonic form of the present notations by ear is in part the invention of the observer.

The accurate observation of a musical performance of any length is beyond the power of the unaided ear. In the limiting case of Mozart's transcription of singing in Rome, what was carried away was the diatonic form of the rendition, not its accidental material. The fractional tone which Helmholtz reports in the call of certain dervishes in Cairo impressed a trained ear as a nondescript blunder until after repeated hearings. The invention of the phonograph has given to science a new field of observation, that of music in the making. Fixed on a wax cylinder in reproducible form, the sequence of tone concerned in a performance of music can now be observed and recorded to within minute intervals. This has been attempted in the present phonographic notations, and during the process and later the melodies were written down currently by ear in the customary musical notation. On comparing the two records, the actual (carefully estimated) notes proved in many cases far from the pitch which the unaided ear assigned to them and which in general brought them within the bounds of the scale. In liberal measure the diatonic garb which Pueblo singing wears to the European hearer is woven by his own musical sense. It is a false show due to his inability to divest himself quickly of inveterate prepossessions of the Western ear, or, as we may say, due to the aberration of an instrument unequal to rapid observation.

The illusions of apperception here illustrated anew are common in all fields of sensation, and may possess any degree of verisimilitude. We recognize as our arbitrary creation the familiar phrase repeated in the rattle of a railway train, or the diatonic melody heard in dropping water. But old-time British tars had doubtless a haunting sense that it was only the imperfect command of the French over human speech that distorted in their mouths the plain injunction "Wheel 'em along" to the outlandish "Ville de Milan"; and the ship's company bringing the Empress Eugénie to England is said to have welcomed the cry "Beef, brandy, and cheese," suggested impromptu by Cecil Rhodes, as the familiar "Vive l'Impératrice" delivered as well as English tongues and channel breezes would permit. The apperceptive task is no greater in the case of melody. To hear any sequence of tone whatever as a rude essay at the diatonic scale, we have to draw any note but a fraction of a semitone from its actual position. When the performers themselves aim at approximate diatonic intervals, the task is still more easily within the power of the group of tones diatonically spaced which are continually sounding in the fancy of the European listener. Of this the subsequent staff notations offer abundant evidence.

(c) *Adiatonic repetition*

Many adiatonic features of the songs are shown to be intentional by repetition.

The curious dress of the following phonographic notations is a development from the attempt at an impartial record of Zuñi melodies, and still more plainly signifies that the writing of music has entered upon a new phase. The extent of the departure of both from the customary staff notation may easily be underestimated. The step taken is no other than that separating the indicative from the imperative mood, the real from the ideal. Written music as otherwise known is not a record of occurrence but of purpose. It expresses a scheme of pitch, time, and stress at which, in the case of music observed, we assume a performer to have aimed, and toward which we direct future performers. The Zuñi notations did not add another to such interpretations, but gave memoranda of observation. They were the roughly

approximate record of certain facts of pitch and time which had been caused to take place under circumstances permitting subsequent study. The present notations record similar facts, with an attempt at much greater exactness. Compared with the customary writing of music, these again are as annals to laws, as a ship's log to its sailing directions.

The chief exegetical value of records of performance lies in the comparison they make possible between different renditions of the same melody, or fragment, by the same or different singers. Repetition argues purpose; and in this music is frequently adiatonic repetition proving adiatonic purpose. In Snake Song No. 1 the singer repeats notes embodying a sequence of four approximate semitones, e-de-d-cd-c, below, and one above a minor third. No. 3 repeats a sequence of two major thirds (four tones) over three semitones, c′-ga-e-de-d-cd. Snake Song No. 6 repeats a semitone below a minor third and in the lower octave two semitones above it, forming the sequence c′-a-ga-d-cd. Anoshkaey repeats a fourth over a fifth divided by semitones symmetrically placed, forming the sequence d′-c′-b-a-fg-f-d. Anonymous II repeats two approximate semitones above and four below a tone, forming the sequence ab-a-ga-f-e-de-d. All of these combinations, and others like them, are impossible within the diatonic scale in any one form, and some of them transcend all the minor forms together.

(d) *Chromatic or modulated structure improbable*

The explanation of the adiatonic features of the songs by accidentals or changes of key demands in many cases an improbably complex use of the scale.

The application of this theory to irregular sequences of tone like these songs involves two steps comparable to lower and higher literary criticism, — the settlement of a text and of its meaning to the authors. The notes intended by the singers must first be inferred before they can be interpreted as accidentals or as steps in different keys; this irregularity being in itself an argument against the possession of any scale-consciousness by the singers. The principle of the inference may be that diatonic intervals are intended; and the melodies seem, at least

at first, to justify this assumption. In working with it, particular care must be taken lest the conception *scale* be substituted for the conception *interval*. *Petitio principii* more adroitly steals the livery of logic to serve unreason in than any other fallacy. On closer study of the melodies, even the legitimate assumption becomes doubtful. More probably these singers aim neither at diatonic intervals nor at any other limited set, but at indefinitely varying approximations to the former, precise only as they are run into the mould of each individual song.

Aside from this probability and supposing a text settled on any assumption (other than that of the point to be proved), it is to be noted that any sequence of tone can be exhibited as moving within any scale if entire freedom as to frequence and position of changed notes be granted; since every note that does not fit can be given the latter standing. But while theoretically admissible, indefinite chromatic freedom is a practical impossibility. The explanation of the adiatonic features of these songs by accidentals will be disproved by showing that the implied interference with the scale is improbable. In the adiatonic sequences just cited, entitled through their repetition to a place in a corrected text of the melodies, this interference sometimes affects several semitones, a degree of freedom hardly credible. Logical parsimony demands a simpler explanation of these songs than a chromatic structure rivaling that of modern European music.

It is to be noted in like manner that any melody restricted to intervals of a given scale can be exhibited as moving within that scale if entire freedom as to change of key be granted. For, if any given transition is impossible from the step with which its start is now identified, it will by hypothesis exist from some other step, and its start needs only to be identified with that; this change of scalar significance being a modulation. As before, the disproof of the explanation will consist in showing not the impossibility but the improbability of the changes assumed. The adiatonic sequences just cited are simply accounted for by the tendency of these singers to move toward or past coming notes, make such combinations as they please, and substitute other

intervals when the need of change is felt. Their diatonic explanation by rapidly succeeding modulations is necessarily a complex one; and still more complex if accidentals also enter. In themselves they give no hint of a scale-consciousness in intricate activity. The combination of fifths in B of Anoshkaey is the only one among them that suggests modulation, and this occurs just before in A without giving the suggestion.

Further, these combinations, and all but one or two of the other repeated phrases of the songs, are more or less changed in repetition by a semitone shifting of the pitch of some but not all of the notes; and this flexibility of structure forms what is apparently a definitive bar to the scalar theory of this music. The effect of the partial shifting is that of a movement of one part of the texture affected on the rest, and its explanation on the scalar theory involves either a modulation transferring the phrase to another part of the scale or a modulation advancing part of it into the new key before the rest. The former case presents the unlikely supposition that a grasp of the scale as doubtfully expressed as elsewhere in these songs, even in the immediate context of the phrases in question, should be equal to changing the scalar significance of all the notes of a phrase upon a change of but one or two in pitch. The supposition of modulation by installments — that of an alternation between two atmospheres represented by parts of two keys in rapidly succeeding instants of passage across a given tract of tone — involves an intricacy of musical thought hitherto unknown even in modern European music, and not easily credible of any.

The major thesis of the "Zuñi Melodies" — that Pueblo music is without scale — is strongly confirmed by this cumulative evidence. The diatonic form of the Hopi songs is (*a*) harmonic necessity or (*b*) apperceptive illusion. In large measure their adiatonic features are at once (*c*) intentional and (*d*) inexplicable by interpolation and transposition.

5. Scales an instrumental product; the voice determining their general form, the ear, hand, and eye their varieties

The minor thesis of the "Zuñi Melodies" — that "in this archaic stage of the art scales are not formed but forming" — is rather weakened than corroborated by a closer study of Pueblo music. Its bent toward change inspires a doubt whether, unless by outward compulsion, it would ever submit to the trammels of a system. It appears an unhistoric rather than a prehistoric art.

Although the voice provides the raw material for scale building, through its tendency toward intervals of simplest ratio, this might apparently remain unused unless in the construction of composite instruments. The process called tuning any instrument giving a number of fixed notes consists in adjusting these notes to certain standard pitches, which might be either absolute or determined by certain music, and in either case would embody a definite interval-order. Music played on such an instrument could also be played on any other embodying the same interval-order, though at a different pitch; and the order might thus obtain a separate existence. Its steps would be recognized and the notes of music viewed as their embodiment. A musical system would have arisen. The five and seven step octave scales of the Eurasian continent, East and West, have their legendary origin in such composite sources of tone, groups of pipes and of strings respectively; and the frequent diatonic sequences of the present songs indicate how these may have received their form from the voice. In particular, a movement dividing a fourth by thirds, as in Snake Song No. 3, Çoyóhim-katcina, Anonymous II, Sumýacoli or Mana, shifted through a fourth, as in Snake Song No. 6, Malo-katcina, or Haikaya, and repeated in a lower octave like the shadow dance to which the lowest notes of these songs often seem the invitation, tends to result in either a five step or the seven step diatonic order. Carried out in all possible ways, the process gives fifteen orders, three being the diatonic seven step octave division, two the five step division formed therefrom by the elimination of its tritonus, "Si contra Fa," two a nine step octave admitting three

tritonuses, and the remainder differing from these and among themselves.[1]

The diatonic order actually emerges in but one of the three cases just mentioned in which a theme is shifted through a fourth. Snake Song No. 6 groups semitones and minor thirds, Malo-katcina juxtaposes two minor thirds. Only Haikaya, by the modulation of a sequence consisting of a minor third following one tone and followed

[1] Expressed in the nearest semitones the divisions are as follows: —

Trichordal fourths		
Major 3d from base	. 1 . 4 . 1 . 4 . 2 .	
Major 3d from summit	. 4 . 1 . 4 . 1 . 2 .	Diatonic octave with tritonus eliminated.
Minor 3d from summit	. 3 . 2 . 3 . 2 . 2 .	
Minor 3d from base	. 2 . 3 . 2 . 3 . 2 .	
Tetrachordal fourths		
Major 3d from base and summit	. 1 . 3 . 1 . 1 . 3 . 1 . 2 .	
Minor 3d from base and summit	. 2 . 1 . 2 . 2 . 1 . 2 . 2	Diatonic octave.
Major 3d from base : minor 3d from summit	. 1 . 2 . 2 . 1 . 2 . 2 . 2	
Minor 3d from base : major 3d from summit	. 2 . 2 . 1 . 2 . 2 . 1 . 2	
Major 3d and minor 3d from base	. 1 . 1 . 3 . 1 . 1 . 3 . 2 .	
Major 3d and minor 3d from summit	. 3 . 1 . 1 . 3 . 1 . 1 . 2 .	
Pentechordal fourths		
Major and minor from base : major from summit	. 1 .1.2. 1 . 1 .1.2. 1 . 2 .	
Major and minor from base : minor from summit	. 1 .1.1. 2 . 1 .1.1. 2 . 2 .	Diatonic octave with tritonuses added.
Major and minor from summit : minor from base	. 2 .1.1. 1 . 2 .1.1. 1 . 2 .	
Major and minor from summit : major from base	.1.2. 1 . 1 . 1 . 2 .1.1. 2 .	
Hexachordal fourths		
Major and minor from both base and summit	.1.1.1.1. 1 .1.1. 1 .1.1. 2 .	

by two others, marks out the diatonic scale less one step, Fa, which the first interval of the final descent supplies by expanding from a fourth to a fifth. It would appear that while still disembodied music tends to remain adiatonic, though always of necessity diatonoid. Only when incarnate by instrumental constraint does it choose, because it must, the best of all possible yokes.

Once thus embodied in composite instruments, other factors than the tendency of the voice toward intervals of simplest ratio influence the development of the scale. The ear may choose equality of tone-distance as an ideal. Instruments being permanent utensils, ease of manufacture, or use, and charm of appearance may influence the make of their parts, the tones they give, and the interval-orders they embody. Scales may result with which the voice has had little to do, giving back to music, at the convenience and pleasure of ear and hand and eye, a semblance of the liberty of its vocal stage.

6. *Character of Pueblo music*

What, then, is the character of this singular music, containing neither a scale nor the promise of any?

(a) *Freedom*

In one word, this character is the freedom which the white race personifies in the American Indian. Apart from the tendency to consonant intervals no metes and bounds to invention manifest themselves in these melodies, and they may apparently be altered by every performer.[1] Such exactness as the songs possess does not lie in the individual intervals which constantly vary and are often exchanged, but in the course of the melodies which sometimes coincide precisely in the repetition at points far removed.

(b) *Melodic instead of harmonic norms.*

These correspondences betoken the attainment of an ideal radically differing from the harmonic precision which

[1] It is a noteworthy fact that the anatomists of the Hemenway Southwestern Expedition found the hyoid bone of the ancient skeletons exhumed on the Rio Salado exceptionally elastic in structure. The position of this bone at the base of the tongue makes it an important factor both in speech and song. (J. L. Wortman and H. F. C. ten Kate, *On an Anatomical Characteristic of the Hyoid Bone of Pre-Columbian Pueblo Indians of Arizona, U. S. A.* Congrès Internationale des Américanistes. Compte Rendu de la 7me Session, Berlin, 1888. Berlin, 1890, pp. 263–270.)

is the first principle of scalar performance. It is as if from any given tone there were to these singers a comparatively narrow but not very intense field of attraction at the octave, others stronger but perhaps more diffused at the fifth and fourth; and at the sixths and thirds such confused and spreading attractions as might be expected from centres elongated but perhaps not clearly separable to the ear, — as a double star may be to the eye. The prominence of sixths is an unexpected feature, and in the form of a sequence of major thirds (Snake Songs Nos. 2 and 3, Jakwaina) unpromising diatonically. These approximate ideals of vocal transition await incorporation in an individual melody to receive exact determination, and then not individually but collectively in the form of the frequent precise adjustments of texture which are so great a surprise in view of the fluctuating and alternating intervals beneath which they are hidden.

(c) *Division, combination, and balance of intervals*

Three complementary methods of composition are suggested throughout the songs, whose movement may be conveniently described in terms of this hypothetical psychology of their invention. Assuming the singer in executing any step of his melody to be guided by another tone than those he leaves and reaches, such an auxiliary note may lie beyond his goal, beyond his start, or between the two. His movement may in the first case be called a division of the interval *start-auxiliary;* in the second, a combination of the interval *start-goal* with the interval *auxiliary-start;* and in the third case, a balance of the interval *start-goal* upon the auxiliary. The division of an interval by a goal near the auxiliary may be called a movement of *approach.* The particular case of combination in which an interior note of a divided interval becomes an extreme of another may be called *lapping.* The balance of an interval upon a coming auxiliary note near its goal may be called *overrunning.* Steps in general thus interpretable group themselves, by repetition, rests, or changes of measure, into movements within which the singer often revisits the pitches touched. The chief movement in Snake Songs Nos. 1 and 8 appears a simple division of a fifth; those of No. 3, Malo-katcina, and Haikaya, in the main simple divisions of

sixths. In No. 6 a divided fifth is combined with an undivided third. The combination of divided intervals is illustrated in Anonymous II by superposed fourths; in Çoyóhim-katcina, by a fourth (extended by a minor third) over a fifth; in Shiashtasha, by a fifth lapping two others superposed; in Anoshkaey, by a fifth lapping a fourth and a fifth superposed; in Jakwaina, by superposed fifths; in Sumýacoli, by doubly lapped fifths. Thirds and fourths are balanced in No. 3, No. 6, Anonymous I, Haikaya, and elsewhere. Maihai-katcina illustrates the extension of a fifth (fourth) to a sixth by a balanced fourth, and the lapping of fifths.

(d) *Thematic development; strophe form; downward course; delivery*

The figures thus elaborated are used as themes; repeated in varied forms (Malo-katcina); shifted in pitch, as well through a minor third (Snake Song No. 6, Anoshkaey) as through the fourth above noted; and in particular expanded (Anoshkaey and Haikaya). The main figures may be preceded by an introduction, separated by interludes, and followed by a finale. The introductions are apt to present anomalies of form, and by suggesting that the singer is laying his course in the song emphasize its freedom of structure. Through their rehearsal of important notes the finales represent *clôtures* in overture form. The general course of the melodies is downward, both within the individual figures and from figure to figure, the rate varying from the gradual descent of Snake Song No. 6 to the notable plunges of Malo-katcina, Maihai-katcina, and Shiashtasha. Snake Song No. 1 and Anonymous Nos. I and II keep their general level throughout, and Çoyóhim-katcina and Jakwaina return to the initial tract after a climax. The singers often attain their highest notes by an approach (Çoyóhim-katcina: D′, C″, D‴) or a flourish also (Shiashtasha, Jakwaina), and in descending likewise often overrun (Anonymous I).

(e) *Mutation*

The partial change in the pitch of repeated phrases, which has already been seen to resist explanation by modulation, is the most noteworthy formal feature of this music. Defining a musical figure as a combination of notes determinate in their relations of pitch, sequence, duration, and emphasis, this process may

be called the mutation of figure, and defined as a repetition in which other pitches are substituted for certain only of those employed at first.

Its varieties

The change is of two kinds: a larger shift of about a semitone, which may affect any of the notes of a phrase, and which is illustrated in almost all of the melodies; and a smaller and less frequent shift of about a quarter tone, affecting only notes whose central position or office as starting-points distinguishes them as axes or bases. The larger mutation may be spoken of as compound or simple according as the shift occurs in both senses about such a cardinal note, or moves all the notes affected in the same sense. Simple mutation may terminate either by the return of the shifted notes, or the advance of the others; or, as they may be called, reëntrant and progressive mutation; to which may be added incomplete mutation, in which neither happens. The smaller mutation may be interpreted as a mark of the sympathy of the whole structure in the displacement of a part. *Compound mutation* is illustrated in Snake Song No. 3, where a triad contracts, expands, and contracts again upon a constant mediant in four out of five recurrences of a melody; and in Anoshkaey and Maihaikatcina, where a movement in a fourth is repeated in a fifth, and then returns to a fourth (in Anoshkaey through a representative in the same tract). *Reëntrant mutation* is illustrated in Snake Song No. 1, where a semitone rise of the summit of a triad is repeated after a like introductory movement, the base being periodically raised a sixth tone throughout the song; in Snake Song No. 8, where the base of a triad descends a semitone in repetition and is restored at the outset of a third performance; and in Shiashtasha, where the mediant of a triad gives and reacts a quarter tone as a semitone shift of the extremes makes the triad alternately major and minor, the rest of the fabric tending to follow them. *Progressive mutation* is illustrated singly by Çoyóhimkatcina, where the basal triad rises a semitone as the song proceeds, the fourth upon it first rising accordingly, then lapsing and again rising, the mediant of the triad yielding and reacting in harmony; and by Jakwaina, where the upper boundary of the main theme first rises intermittently, later the lower boundary, and finally all the notes perma-

nently. Multiple progressive mutation is illustrated by Snake Song No. 2, where a semitone rise in the extremes of a triad is followed by a similar rise of the mediant, the extremes adjusting themselves as at first, and the mediant thereupon rising again; and in Snake Song No. 4, where the mediant rises by successive quarter tones in four out of five repetitions of the melody, the extremes alternately delaying and following. *Incomplete mutation* is illustrated in Malo-katcina as performed by Kano, where the lower extreme of the theme is raised a semitone in repeating it; by Anonymous II, where each of two superposed fourths exhibits in the repetition the predominant division that was originally predominant in the other; and in Sumýacoli, where the lower notes of each of two themes rise a semitone in the repetition. Neither in Malo-katcina nor in Sumýacoli is the arrest of mutation definitive, for in codas to those songs the outlines (or octave outlines) of the themes, though not the figures themselves, appear completely shifted.

Three songs of the seventeen show no important mutation of figure and no displacement of a cardinal note. The modulation of the theme through a fourth seems to engross the thoughts of the singer of Snake Song No. 6, and this he executes again with precision, diverging now and then rather by an inveterate habitude of variety than by definite purpose. Haikaya also modulates the theme through a fourth, and also repeats the process without any variation indicative of purpose, although a final access of fervor stretches the modulated figure beyond all bounds. Anonymous I repeats without mutation a loose-jointed melody, that forthwith expands or contracts every step it takes. These instances in which the impulse to vocal freedom, denied expression in the larger features of the songs, finds an outlet in the smaller, makes their exposition of the device of mutation complete.

Its motives

Mutation results in the substitution of other intervals for all those formed by a certain pitch or certain pitches in the figure shaped. The initial change of span, if not a chance result, may be ascribed to caprice, to a desire for novelty, or to pleasure in vocal skill; and the correspondingly altered span of subsequent movements involv-

ing the pitch of the shifted note may be referred to the attraction of the after image of its new position. Doubtless these motives all enter, but not alone nor even chiefly. A completely satisfactory account has perhaps not yet been given of the emotional contrast to European feeling between the major and the minor modes of the scale. The fact remains that a semitone alteration of a phrase may change it from an expression of exaltation to an expression of depression. Mutation presents such changes, varied and multiplied. It appears a generalization of modality, affecting not one or two steps in an otherwise invariable standard of pitch combination, but any part of indefinitely various orders marked out by a melodic movement free of all guidance other than that of approximate consonance. Such a generalized expansion and contraction of intervals would seem to promise an indefinite enrichment of the emotional expressiveness of combinations of tone. A melodic music of fourths (of which a chain of two might mark out a five step octave), like the diatonic music of fifths, but with an inverse expressiveness, is suggested by the use of the major trichord to carry a drooping movement like Mana, and the minor to carry a vigorous turn of phrase like the opening of the repetition of Anonymous II. All the pathetic charm which Pueblo singing possesses to European ears is assuredly there, and much beside that does not penetrate the diatonic sense.

With its amplified emotional expressiveness mutation combines another important source of effect, that of the reappearance of the familiar. The shaped fabrics demand to be restored in form and mood, as all music and all poetry demand the return of the same. This motive also is fruitfully used by the Hopi singers. Apart from the charm their songs possess at a single hearing, and from the varied emotional suggestion resulting from their mutability, they are full of imaginative expression, based on the multifarious ways in which the natural end of their mutation is withheld, delayed, or conceded.

Inference concerning these possible moods and images must be largely conjectural; only the orderly variety of form which invites it is a fact. In Snake Song No. 8 the fall and momentary recovery of the base of the tetrad vividly picture depression. A mind at rest is

suggested in No. 3 by the rhythmic expansion of the theme both ways from a constant axis, and the undisturbed course of the second theme meanwhile; and a like balance by the slow reintegration of the tetrad in No. 1. Anoshkaey at once expands and shifts its theme, occupying the same zone later with a contracted phrase, and becoming by these duplications of movement a type of reality and appearance. Shiashtasha moves between major and minor versions like the shuttle of the Fates, inclining neither way, the one phase leading back into the other through a neutral interlude; neither plainly the beginning of the song, and perhaps the neutral interlude the end. In Jakwaina the movement upward begins in a leap beyond, instead of to a previous limit, and the pursuit of this vivacious initiative through a motley sequence of themes displays the *verve* of the singer and symbolizes a persistent and successful struggle. A diffident opening and a confident close mark Anonymous II, of whose effect, dependent in part upon its portamenti, no simple account can be given. The expansion of the theme of Maihai-katcina from a fourth to a fifth, taken together with its other mutations, its inverse rhythm, and its conclusion, make up a dialogue of moods like Tennyson's "Two Voices." In Ço̧yóhim-katcina, where a movement in a triad is shifted upward, and movements in a fourth above give place to it, close down upon it, and finally adjust themselves to it, the upper third of the triad at the higher pitch forms by itself (at first augmented to major) a long introduction to the melody, whose course thus appears its temporary defeat and final victory. In Malokatcina the shaped figure is not restored, but a coda outlines in the lower octave the tract within which it would move were the semitone shift upward complete; and the expression of the song mainly resides, to our apprehension, in the unexpected source from which its deliverance comes. Sumy̆acoli ends likewise. The two figures are not themselves restored, but the tracts they would occupy are outlined in a coda, which seems to bring their release from duress. The two remaining songs are buoyant in quality throughout. In Snake Song No. 2 repeated vigorous shifts upward by the extremes of a triad incite the mediant to take the lead. The leadership of the mediant from the

start in similar smaller movements gives No. 4 the terraced rise of the cliffs among which the Hopi live.

These wild flowers of fancy, the wanton yield of a naïve delight in the vocal production of interval, will not long survive the spread of European music throughout the Americas. Even the singers themselves will accept instrumental substitutes from which they delicately and intricately differ. It is a satisfaction to reflect that the memory of a few will be approximately preserved in the pages of this *hortus siccus*. Under the microscope they exchange the aspect of transplanted weeds for that of a native flora. Doubtless songs like these once lent solemnity to Aztec rites and graced the state of Inca kings.

II

THE PHONOGRAPHIC METHOD

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The following account of the method of the present notations was written immediately after their completion. Their subsequent study has brought to light coincidences of form evidencing an accuracy of reproduction by the phonograph even greater than could at that time be inferred.

The largest variation in the speed of the instrument observed during the process of notation — a ratio equivalent to a tenth of a tone on eleven occasions — does not affect the interpretation of any song; and several exact repetitions of notes within the regions involved indicate that the aberrations may sometimes have been narrowly ephemeral. A correction is definitely indicated in one instance only. In Sumýacoli a fall in the phonograph rate equivalent to a twentieth of a tone (following another of an equal interval) is registered between the two slides of A″; and had the instrument remained as constant here as between the two slides of A′, the pair in A″ would doubtless have been judged as nearly identical in pitch as that in A′.

It is remarked in the sequel that the chief motive of the unusual effort there described to note these songs accurately was not a love of accuracy for its own sake, but a hope that some proportion of the resulting close determinations of pitch might prove significant. The study of the first song fulfilled this hope by bringing to light the novel habitude of performance for which the name mutation has been chosen, and which proved characteristic of the series. The discovery transferred the focus of the inquiry from the intervals used, on which light had been awaited, to the use made of them, — a new and widely different topic. Undertaken in the interest of a view of this music still largely harmonic, the notations proved to indicate that not harmony but melody was its basis, not individual intervals but larger form its essence. This discovery of a musical method important both in theory

and practice amply justified the labor which had made it possible; the more amply because of the unlooked-for character of the new fact.

1. *Actual music first accessible to scientific study through the phonograph*

The notations presented herewith differ from all others known to me, excepting the collection of Zuñi melodies I have already published, in being notations of performances and not of pieces of music.[1] This difference is one of importance, involving no less a distinction than that between facts of observation and theories upon them. A fact of observation is anything that is observed; a theory is the idea that something would be observed under specified conditions. A musical performance is a real event open to observation like any other; a piece of music is an ideal of event which any given performance more or less completely realizes.

The exacter notation of musical performance by the naked ear may be said to be practically impossible. None but the most exceptional observers would be equal to the task of writing down with any pre-

[1] The year after the appearance of the *Zuñi Melodies* I contributed to the *Philosophical Review* (1892, vol. i, Nos. 1 and 2) a paper entitled "Some Psychological Aspects of the Chinese Musical System," containing notations of Chinese performances of which I had myself obtained phonographic records. In these notations a mean of closely grouped notes was assumed as the pitch intended by the performer. Within the past few years the closer examination of musical structure with the aid of the phonograph and by a similar method has been continued in the Psychologisches Institut of Professor Carl Stumpf at Berlin University, by Professor Stumpf, Dr. E. M. von Hornbostel, and Dr. O. Abraham, using records collected by themselves and others. The published results of these studies include C. Stumpf, "Tonsystem und Musik der Siamesen," *Beiträge zur Akustik und Musikwissenschaft*, 3 Heft, 1901; E. M. von Hornbostel, "Phonographirte Tunesische Melodien"; "Notiz über die Musik der Bewohner von Sud Neu Mecklenburg"; also an essay on the present state of the science of Comparative Music contributed to the Bericht of the Basler Kongress of the Internationale Musikgesellschaft, 1906. O. Abraham and E. M. von Hornbostel, "Phonographirte Indianermelodien aus British Columbia," contributed to the Boas Memorial Volume, New York, 1906. I regret that the limits of my leisure forbid more than the mention of these inquiries.

tense at minuter exactitude a tone sequence of any complexity from a single hearing. In particular, all direct study of musical forms unfamiliar to the observer must proceed as it has proceeded, by a process of the correction of an original notation by repeated hearings of the music noted. This process does not result in a record of the facts of any one or any number of the performances tributary to it; but is a record of the observer's idea of what the performers of certain observed sequences of tone would have performed had their execution perfectly corresponded to their intention, or (perhaps) had their intention not wandered also from a certain norm. In a word, a notation made by ear from repeated hearings does not report observations, but presents a theory of observations.

The present notations have also been taken down from repeated performances; and, moreover, from performances of a mechanism, and not of musicians. But this mechanism is an apparatus by which, as it is claimed, many musical performances can be given which shall not perceptibly differ, except perhaps in tone quality, either among themselves or from an original performance having another source to which the instrument shall have been exposed. Admitting this claim, such performances are for the most important purposes of purely musical observation recurrences of their original, and records made from them are records of facts of observation which this has presented. Such notations as are given herewith might accordingly be described as the record of conclusions from many observations of one and the same set of facts. This set of facts being any sequence of audible event to which the instrument may have been exposed, the phonograph thus makes possible a hitherto unheard-of thing, the detailed study of an individual performance of music. It opens a field of investigation, that of the actual events of which music consists, which has hitherto been accessible to observation in only a very limited way, — while a performance lasts, and in so far as it can afterward be recalled in memory. The study of performance is created, it may be said, as a branch of the exacter investigation of the art of music, through the invention of the phonograph; always provided that phonographic reproductions may be

made at least in the most important respects and for the most important purposes indistinguishable among themselves and from their original.

2. *Tests of the phonograph*

In testing this assumption, the main question to settle is that of the degree of accuracy with which the phonograph repeats a sequence of intervals. For accuracy in the reproduction of intervals means that the instrument gives back air waves in time relations which are closely like those incorporated in the vibrations constituting the original performance, and this involves a due reproduction also of the larger time structure of the music. These two formal elements, relations of pitch and relations of time, are the fundamental ones in a musical product; the material element, the quality of the sounds, being of subordinate importance. Music is an art of interval and measure primarily, and one of timbre secondarily. As at present constructed, the phonograph is noticeably deficient in the reproduction of delicate shades of timbre; and this shortcoming may easily lead to an underestimate of its possible value as an aid in musical investigation. Purity and variety of tone quality being important sources of pleasure from music, the phonograph may seem at first hearing to reproduce structures of tone with essential elements lacking; or it may be that we argue from this conspicuous imperfection of material to a corresponding distortion of form.

What little acquaintance I had with the phonograph before learning of Dr. Fewkes's collection of records sufficed to make their study seem to me well worth while. These records had, it is true, been taken on a phonograph run by a treadle, but the experiments detailed in the "Zuñi Melodies" went to show that such records when reproduced by the electric motor and storage battery would only very seldom be noticeably at fault. For the latter motor used both in record and reproduction, the experiments indicated that the error would never be as great as the eighth of a tone. Later, in studying by the phonograph the Chinese performances before mentioned, I made another effort to determine by ear the amount of the distortion to which a sequence of intervals might be expected to be subjected by the phonograph used with a

storage battery. An account of this test is given in an appendix to my paper on the Chinese Musical System. The test sequence employed (which could as well be one as another) was a sequence in unison without any interruption of the sound, that is, a single note held continuously until the inscription covered the cylinder. I sought to determine how far this varied in the reproduction from perfect constancy of pitch by tuning the phonograph note between two others (notes of the instrument called the Harmonical), which could be sounded at will for comparison, and which were one ninth of a tone apart. In some of the trials I found it impossible, even by the use of this delicate criterion, which I convinced myself would enable me to detect variations of very much less than this small fraction of a tone, to be sure that the phonograph note had changed its pitch at all during the entire reproduction.

This unexpected result led me to preface the following study of the second collection of phonographic cylinders obtained among the Pueblo Indians by Dr. Fewkes, who this time used an electro-motor and storage battery, with a series of tests not psychological but physical. I endeavored both to find the principal limitations of the instrument by the trial of various conditions of inscription and reproduction, and to determine the degree of exactness of its best performance. The method consisted mainly in noting the amount of variation in the rapidity of the pulsations of sound called beats produced between a phonographic reproduction of a note held continuously and another note known to be of constant pitch.

A general expression for the distortion by the phonograph of the intervals of any sequence of tones may be reached as follows: Consider any tones μ and ν of a sequence phonographically inscribed. Let the rate of the cylinder during the reception of the air waves concerned in the production of μ be denoted by the term I^{μ}, and the like rate for ν by I^{ν}. If in the reproduction the rate of the cylinder while the needle traverses the inscription made by the air waves of μ is I^{μ}, and while it traverses the inscription of ν is I^{ν}, the two rapidities of vibration imparted to the diaphragm from within will be the same as it received from without in the original performance of the music. But further, the ratio of these rapidities of vibration will be unchanged when the

cylinder moves during the reproduction of μ at any velocity R^{μ}, if only it moves during the reproduction of ν at a velocity R^{ν}, which is the same multiple of I^{ν} as R^{μ} is of I^{μ}. That is, while any two tones of a sequence will be reproduced at the original pitch only when the reproducing needle traverses the inscription of each at the rate the inscribing needle moved in making it, they will be reproduced at the original interval whenever the second moves in each case at the same multiple of the rate of the first.

Supposing for a given reproduction we have

$$(1) \quad R^{\mu}=aI^{\mu}$$

$$(2) \quad R^{\nu}=bI^{\nu}$$

we have then

$$\frac{a}{b}R^{\nu}=aI^{\nu}.$$

That is, had the velocity of the cylinder during the reproduction of ν been $\frac{a}{b}$ times what it was, the tone ν would have been given at the interval from μ at which it occurred in the original music. But the rapidities of the impulses communicated to the diaphragm by the same inscription of tone at any two velocities of the cylinder will be to one another as these velocities. The ratio of these latter will then be that of the vibration numbers of the two tones obtained in this way from a single inscription; that is, it will be the interval through which the tone is changed by the change of rapidity. The ratio $\frac{a}{b}R^{\nu}\div R^{\nu}$, or $\frac{a}{b}$, will then be the interval by which the reproduction of ν differed from a pitch at which the original interval of μ to ν would have reappeared. It is the amount of distortion or error of the interval $\frac{\mu}{\nu}$ in the given reproduction. Denoting this by Δ^{μ}_{ν} we have

$$(3) \quad \Delta^{\mu}_{\nu}=\frac{a}{b}.$$

But from (1) we have $a=\frac{R^{\mu}}{I^{\mu}}$, and from (2) $b=\frac{R^{\nu}}{I^{\nu}}$.

Whence

$$(4) \quad \Delta^{\mu}_{\nu}=\frac{I^{\nu}R^{\mu}}{I^{\mu}R^{\nu}}.$$

The ratio of the inscription velocities and the ratio of the reproduction velocities of the cylinder for two given tones of an inscribed sequence may then be regarded as two variables on which depends the error of the interval between these notes in a given reproduction. In estimating the element of phonographic distortion, not only the variation in the speed of the cylinder at the time of reproduction is to be taken into account, but its changes of rate while receiving the inscription.

The span in pitch of an interval is smaller as its ratio approaches unity, becoming zero at this ratio, in the interval of unison. The amount of a distortion Δ^{μ}_{ν} will therefore be zero when the product of the ratios $\frac{I^{\nu}}{I^{\mu}}$ and $\frac{R^{\mu}}{R^{\nu}}$ is unity. This will occur when one of these ratios is the reciprocal of the other, that is, when the variation in the rate of the cylinder from μ to ν is in the same proportion in the reproduction as in the inscription. When this ratio of variation is unity, we speak of the rate as constant. A constant speed in both inscription and reproduction is therefore a special form of the conditions for an undistorted copy of an inscribed music. Moreover, according as the product of the above ratios approaches unity, that is, as one comes nearer to being the reciprocal of the other, the distortion Δ^{μ}_{ν} will be smaller. A special form of these conditions is given in the close approach of both ratios to unity. In other words, the distortion of a texture will be inconsiderable when in both its inscription and its reproduction the rate of the phonograph has varied very little from perfect constancy. Further, the motor of the phonograph being specially designed to give the cylinder as nearly constant a velocity as possible, this proposition may be simply converted, and we may affirm that if a texture of tone is little distorted in phonographic reproduction it is because the rate of the instrument has been very closely constant during both inscription and reproduction. The following observations of Δ^{μ}_{ν} where μ and ν are different segments in the reproduction of a constant note accordingly afford data for estimating the degree of approach of the phonograph cylinder to constancy of rotation during the performance of each of its functions.

The physical cause of tone is the regularly periodic vibration of the body producing it, this vibration being more or less rapid according as the tone is higher or lower in pitch. It is found that if two tones sufficiently near together in pitch be produced simultaneously, the resultant sound is no longer constant in intensity, but regularly waxes and wanes. The number of these pulsations, or beats, as they are called, in any given time proves to be equal to the difference between the numbers of vibrations executed in this time by the two sources of tone employed. If the united sound makes in ten seconds forty pulsations, the one tone is produced by four more vibrations per second than the other.

Let us suppose a sounding body giving a tone which cannot be certainly affirmed on the testimony of the ear to change its pitch. If we are in possession of a source of tone of nearly this pitch, whose rate of vibration is known

to be constant, we can determine whether the rate of vibration of the other varies, by noting whether the pulsations made by the two when sounded together are subject to change. For since the one source vibrates at a constant rate, a change in the rapidity of the beating of the two will mean that the other is vibrating slower or faster than before. In this indirect way variations in pitch may be detected which would entirely escape notice by the ear. Moreover, if the vibration rate of the source producing the constant tone be known, we are enabled to determine also the interval which the variation in pitch of the other represents, for this interval is expressed by the ratio of the vibration rates of the note before and after the change; and these are found by adding to (or subtracting from) the number of vibrations per second executed by the constant source the number of beats formed with it by the varying source before and after the variation.

The constant source of tone which I used in applying this test to the phonograph was a tuning-fork by Koenig of Paris making 250 vibrations per second, that is, giving the pitch called by the French Ut_3. The phonographic inscriptions which were compared with it were taken from the middle c′ of a Mason & Hamlin harmonium, a pitch higher than Ut_3 by a fraction of a semitone. This note was in each case held uninterruptedly until the inscription covered the cylinder.

There are two possible sources of variation from a constant pitch in such a reproduction as this. While the phonograph may not give back accurately the sequence of pitch it received, there may also have been a variation in the original note. The pitch of a note produced as in the harmonium, by the action of a current of air on a reed, is found to vary somewhat with the strength of the current employed. In order to estimate what importance should be attributed to this factor of original variation, when all possible care was taken to keep the inscribed note constant in intensity, I compared the beats made with the Ut_3 fork by the nearest semitone on the harmonium at its faintest and at its loudest. The note b, when just audible, made with the fork, which was slightly higher in pitch, eleven beats in ten seconds; when given with all possible intensity, twenty-two beats in ten seconds. The greatest possible change which could be produced in the vibration rate of the reed by differences of intensity of blowing was therefore but little over one vibration per second, corresponding at this pitch to an interval of about one twenty-ninth of a tone. The original variation being so small when the conditions were made as unfavorable as possible, I concluded that when all possible care was taken to make them favorable it might be neglected; and that any irregularities which should

reveal themselves nevertheless in the reproduction of the test inscriptions might be laid to the charge of the phonograph.

In taking the first inscription (Cylinder A) the screw regulating the supply of electricity was adjusted so that the shaft of the phonograph made about 140 revolutions a minute. At this rate the needle took over three minutes to cover the cylinder. About two and a half minutes being, I am told, the standard time, the instrument was running during the inscription of Cylinder A considerably below what is considered its normal rate. In listening to the reproduction the mingling of the air waves from the phonograph and the fork was effected by attaching another pipe by means of a hard rubber Y to that leading from the phonograph diaphragm to the ear-piece, the free end of this secondary pipe being favorably placed for the reception of sound from the fork. In the phonographic note itself the rhythm of intensity which I had noticed in using the instrument before reappeared in some slight degree, seeming now in general a double wave with a period equal to that of the revolution of the cylinder. This rhythm of intensity, accomplishing itself in the course of a revolution of the cylinder, is plausibly to be explained as the result of a slight difference in the nearness of the diaphragm to the surface of the wax at different points in its circumference. This would be the result of any deviation of the cylinder from perfect circularity, or any want of coincidence between its axis of rotation and its axis of form. If this is its origin, some pulsation of this kind is to be generally expected in a phonograph note. In later observations I seemed to notice that at higher rates of the speed of the instrument this pulsation of the note was less distinct. Accompanying the tone I could detect two distinct currents of noise: one irregular, like a stream of sparsely scattered pebbles; the other a continuous mild grating noise. This latter exhibited the double rhythm sometimes very distinctly; but it seemed to me I could hear it also in the tone itself.

During two days in which I studied Cylinder A I found difficulty in so arranging the apparatus as to bring out the beats between the two notes distinctly. Although I seemed to be able to detect them as a shimmer of sound through the grinding pulsations of the phonograph note, yet I could not always be sure that I was not at times counting the mechanical instead of the auricular beats. Moreover, they sometimes escaped me through their irregularity; now and then becoming unaccountably fast, fusing into a slow whir. Indeed, on attending to the pitch of the note, I found it to be varying perceptibly. Since the speed of the cylinder was below the normal rate, this fact could be interpreted as pointing to one of the limits of the accurate performance of the instru-

ment. At so slow a rate as 135 to 140 revolutions per minute, the motor could no longer perhaps be depended upon to give the cylinder a constant speed. The trial of different rapidities confirmed this conclusion. The electrical supply being reduced until the cylinder made on starting but 72 revolutions a minute, the note wandered over a wide interval, during most of the reproduction a minor third, but at the end becoming a sixth. At 120 revolutions the variation, while unceasing, kept within comparatively narrow limits, perhaps a quarter tone or somewhat more. In trying the same cylinder again on another day at 135 revolutions, I estimated the variation at nearly if not quite a semitone from first to last. Sometimes a change up and back through perhaps an eighth of a tone took place in a few seconds, but the general rule seemed to be a change to a new level, which it thereupon held for some time. At 158 revolutions the same cylinder showed a total variation which I estimated at less than a quarter tone, and perhaps not much more than an eighth, — certainly within an eighth during much the larger part of the cylinder. After trying 120 revolutions on the day before mentioned, I set the instrument at 180, the result being that the note seemed to the ear quite steady.

Since at this speed the pitch of the record on Cylinder A was far removed from Ut_3, I took on the day after an inscription of the harmonium c′, at 176 revolutions, Cylinder B. In order to make the reproduction beat with Ut_3 with sufficient slowness to be easily counted, this rate had to be reduced to 170. At 174 revolutions I found the needle covered the cylinder to the very end in just two and a half minutes. We may then take 165 to 175 revolutions as the standard speed, and Cylinder B as a standard cylinder both in the inscription and when it was reproduced to beat with Ut_3.

The beats became most distinct when the auxiliary tube was introduced into the resonator of the fork, a minimal tone being produced from the latter by gentle taps with the finger near the junction of the tines. Under these conditions I examined a quadruple series of reproductions from B, the regulator screw being untouched meanwhile, and the time between one and the next being only that required to replace the diaphragm at the head of the cylinder. As the needle took something over two minutes to traverse the inscription, this was a nearly continuous test of the performance of the instrument during a lapse of about ten minutes. The number of beats in those ten second spaces in each reproduction during which I was able to count them were as follows: —

SERIES I	23 (?)	10	9	8
	10	9	10	9
	10	8	10	8
	12	12	15 (?)	8
	12	12	14	11
	11	12	20	13
	16	16	14	9 (?)
	16	16	15	
	15		20	

In Appendix XX to Mr. A. J. Ellis's translation of Helmholtz's "Sensations of Tone," he has given methods by which the number of cents covered by any interval may be calculated from its expression as a vibration ratio. The following table gives the span, in cents, of intervals covering multiples of the tenth of a vibration up to thirty, in the neighborhood of 250 per second: —

Tenths of a vibration	Cents	Tenths of a vibration	Cents	Tenths of a vibration	Cents
1	1	11	7	21	14
2	1	12	8	22	15
3	2	13	9	23	16
4	3	14	9	24	16
5	3	15	10	25	17
6	4	16	11	26	18
7	5	17	12	27	18
8	5	18	12	28	19
9	6	19	13	29	20
10	7	20	14	30	20

Leaving out the rate 23 as doubtful, the phonographic note made, at the beginning of the first reproduction of Series I, one beat per second with the fork; and toward the end, 1.6 beats. The variation here amounted then to .6 of a vibration, and according to the above table covered an interval of 4c, or the fiftieth part of a tone. In the second reproduction it was .8 of a vibration, or 5c; in the third, 1.1, or 7c; and in the fourth, .5, or 3c. The lowest rate of beating counted at any time during the ten minutes was 8, the highest 20, in ten seconds; the total span of the variation noted in the ten minutes being accordingly 1.2 vibration, or 8c, that is, one twenty-fifth of a tempered tone. During the ten second spaces the beats were not entirely regular, a certain momentary hurrying and slackening of them being occasionally noticeable.

Still, as far as I could judge, these ephemeral changes did not represent a variation extending much if at all beyond the limits expressed in the above figures.

To verify these results, I made in the afternoon of the same day two more quadruple series of reproductions, the conditions of the experiment remaining the same, excepting that now I counted the beats only in alternate ten seconds of the reproductions. The intermediate spaces (during which I had occasion to notice no marked divergence from the rates counted) I employed in writing down the number just counted, in assuring myself that what I was counting was really the beats and not any pulsations of sound from the phonograph, and in tapping the fork again. In Series II and a single reproduction observed after it, the sequence of beats was the following: —

					Single (slower) reproduction
Series II	20	20	19	19	12
	22	22	21	19	13
	22	23	22	22	15
	26	24	24	23	15
	26	27	23	21	18
	31	28	26	26	18
	30				
	—	—	—	—	—
Individual variations,	7c	5c	5c	5c	4c

Total variation in Series II, 1.2 vibr. = 8c. These results are almost identical with those of Series I.

Before the fifth reproduction I turned the regulator screw down, slightly diminishing the electrical supply. The slowing of the beats which followed shows that the phonograph note was in this trial *above* the fork Ut_3 in pitch.

This second attempt to watch the beats closely during several reproductions, made under conditions more favorable to the correctness of the observations than I had before devised, revealed the same quickening from the beginning to the end of the cylinder that was noticeable in the first series. The other form of inconstancy, an occasional hurrying or slowing within the ten second spaces, was also again remarked. While this time I judged it to represent a somewhat larger range of momentary variation in pitch than is exhibited in the above figures, it was never sufficient to interfere with the easy counting of the beats. In both these series, especially noticeable is the close return of the phonograph to one pitch each time the diaphragm was brought again to the head of the cylinder. The four initial vibration rates in 1 differed (leaving out 23) by

only $\frac{2}{10}$, in II by $\frac{1}{10}$ of a vibration. The corresponding interval, about one cent, is probably as small a pitch difference as even the best ears under the most favorable circumstances could detect. Indeed, in this part of the scale no one has yet been found able to discriminate tone to $\frac{1}{10}$ of a vibration (cf. Stumpf, "Tonpsychologie," ii, p. 552).

Series III gave, under the same conditions, the following figures for alternate ten second spaces during each of four continuous reproductions: —

Series III	11	11	9	10
	12	12	11	11
	14	14	14	13
	14	13	13	13
	14	15	13	14
	18	18	18	17
	—	—	—	—
Individual variations,	5c	5c	6c	5c

Total variation during Series III .9 vibr. = 6c. After the series was completed I tried the effect of bearing down with the hand on the regulator screw without turning it. The result was a relaxation in the rapidity of the beats, which became faster again when the pressure was relaxed. Since this pressure on the screw produced minimally the same effect as would follow in greater degree from turning down the screw, this slowing of the beats proved again that the phonograph note was above that of the fork.

The result here was almost exactly the same as before, the note being if anything a little more constant. The initial pitches differed by $\frac{1}{5}$, the final by $\frac{1}{10}$ vibration. As in I and II, the change in the beats is a gradual quickening from beginning to end of the cylinder.

These three tests indicated that, while under favorable circumstances a constant note would at the same spot in the cylinder be given in several immediately successive reproductions at the same pitch to within an almost imperceptible fraction of a tone (in general not more than $\frac{1}{100}$), the instrument was subject to a constant aberration, a sharping of pitch, as the reproduction went on by a much larger though still very minute interval, not more than about $\frac{1}{40}$ of a tone.

During all of the tests thus far described, the motor of the phonograph had been supplied with electricity from a single storage battery (Battery 1) of 150 amperes. On taking up the experiments again after an absence of ten days, during which time the phonograph and the battery had stood idle, I obtained from Cylinder B very different and much inferior results to those just reported. Since it was now two weeks since the battery had been charged, I concluded

these were signs of its exhaustion. I continued the tests, nevertheless, in order to ascertain what form the aberrations of the phonograph would take under these conditions. While the beats still kept during a good part of the reproductions within limits approximately those just determined, there were constantly recurring moments of much wider change of rapidity. They would suddenly quicken into a whirring sound, returning after a few seconds to approximately the former rate. On listening to the tone, the absolute constancy of the earlier trials had given place to occasional marked unevenness of pitch. The following are such fragmentary notes of the course of the beats as I was able to take; tests united by a brace signifying as before continuous series of reproductions: —

11	8
13	17
13	13
15	14
18	18
5c	5c

Total variation, 7c.

10	15	18
14	13	19
14	22	15
15	14	18
16	24	20
20	22	
7c	7c	3c

Total variation, 9c.

8	13	15	9
12	14	15	9
Whir	14	22	11
	18	15	13
22	15	17	Whir
20	18		16
—	—	—	Whir
	3c	5c	

10	5(?)	11	10
10	8	12	17
13	9	12	15
12	10	Whir	18
Whir	13		
18		19	
—	—	—	—
	5c		5c

17	8	7	?	25
17	12	7	3	26
18	14	8	5	30
14	15	8	4	36
	17	10	9	20
	17	12	8	31
3c	6c	3c	3c	7c

Total variation, 10c.

Phonograph below fork

24	16	29	30	38
18	17	33	20	37
17	21	35	25	36
16	22	41	31	35
23	22		23	36
	31		33	32
5c	10c	8c	7c	4c

Total variation, 17c.

It was noticeable that while a tendency to raise the pitch of the note from first to last, and through about the customary interval of $\frac{1}{40}$ of a tone, could still be discerned in most of the reproductions, it was seldom a continuous sharping. In one or two of the earlier reproductions the sharping was only minimal, and in one or two of the later the change became a minimal flatting.

The fresh battery (Battery 2) which I obtained in place of the one that now seemed exhausted I was again prevented from using during a month, and upon trial at the end of that time it gave equally unsatisfactory results with Cylinder B, the note varying audibly. Another smaller battery (Battery 3) of 75 amperes, which had also been standing idle during this time, gave better results, in that no whirring of the beats occurred with it. Two quadruple series with it gave the following figures: —

16	24	19	20	24	21	19	19
18	22	23	26	24	24	20	20
17	20	30	28	38	28	25	26
18	22	30	26	40	28	21	24
	24	40	32	38	31	20	27
—	—	—	—	38	37	18	30
1c	3c	14c	8c	—	—	—	—
				11c	11c	4c	7c

Total variation, 16c = $\frac{1}{12}$ tone. Total variation, 15c = $\frac{1}{13}$ tone.

Here, again, in two cases the sharping from first to last is lost.

Three days thereafter I obtained a fresh battery (Battery 4) of 150 amperes and tested Cylinder B again. But on listening to its note I found that the element of noise in it had become markedly predominant over the element of tone. I concluded that I was here in contact with another of the limitations of the phonograph, that of the durability of a cylinder. The trace of the inscribing needle on the wax was evidently beginning to wear out. While in the earlier part of the inscription the tone was still strong, perhaps because that part of the cylinder had been less often examined, it rapidly weakened into almost pure noise. Conceiving that I had made all the use I could of Cylinder B, I turned my attention to the further examination of the limit of speed of revolution for the best results.

On Cylinder C I inscribed the harmonium c′ at 150 revolutions. Two quadruple series gave the following figures: —

Cylinder C (inscription 150 revs., reproduction 146)

19	16	18	18	15	14	14	11
23	28	25	20	21	23	16	19
16	11	10	14	3	7	5	(0?)
15	21	18	12	13	13	8	8
24	24	23	25	25	19	15	16
31	26	31	30	23	21	19	23
13	6	8	9(?)	8	12	10	12
—	—	—	—	—	—	—	—
11c	15c	16c	14c	15c	11c	9c	16c (?)

Total variations, 17c = $\frac{1}{12}$ tone. Total variations, 17c.

The average variation in these reproductions is not much above a sixteenth of a tone (12c). This is only about half the amount of variation to which I judged (by ear) a reproduction at 158 revolutions of Cylinder A (taken at about 140 revolutions) to be subject, in studying this cylinder at the beginning of the experiments.

On Cylinder D I inscribed the harmonium c′ at a very high rate, 218 revolutions. This proved an unmanageable speed, owing doubtless to mechanical conditions connected with the action of the screw regulating the supply of electricity. I found it impossible to tune the phonograph note to the Ut_3 fork in such a way as to give beats easy to count, a very small movement of the screw producing a comparatively large change in the pitch of the phonograph note.

I then took a like inscription on Cylinder E at 184 revolutions. This proved manageable, a quadruple series of reproductions giving the following figures: —

25	25	25	24
20	28	25	27
24	27	25	26
21	22	28	24? (Whir)
24	20	18	21
	23	24	24
—	—	—	—
3c	5c	7c	4c

Total variation for series as far as expressed in these figures: 1 vibration = 7c = $\frac{1}{29}$ tone.

In this cylinder (reproduced at 175 or over) there were two spots where the beats quickened for a time to a rate much above these figures; the first about

5″ from the beginning and lasting perhaps 3″, the second about halfway through the reproduction and lasting perhaps 5″. The first time I estimated the rate of beating at about 50 in ten seconds; the second time they became a whir, and to the ear the note was flatted perhaps $\frac{1}{8}$ to $\frac{1}{4}$ tone. With the exception of these two irregularities the reproductions were, as the figures show, extremely correct, their average variation being about $\frac{1}{40}$ of a tone. But at this faster rate of revolution (record 184, reproduction 175+) the progressive sharping of pitch which had been so regular a phenomenon, at least at first in Cylinder B (record 176, reproduction 170+), had disappeared. In one reproduction the phonograph note had ended (as far as this method of examination enables us to judge) on precisely the same pitch on which it had begun, and in the other three on a pitch not differing by more than $\frac{1}{200}$ of a tone.

I concluded to make another trial with Cylinder B, the tone of which, though almost lost to the ear, might still be strong enough to make beats that could be counted. The point of interest was to discover whether, with a comparatively fresh battery, the sharping persisted. A quadruple reproduction gave the following figures, the beats being perfectly distinct: —

SERIES IV. Cylinder B (inscription 176 revs., reproduction 170+ revs.)

	12	15	13	16
	14	15	14	15
	17	18	17	18
	16	17	20	19
	15	20	16	16
	22	22	24	23
	—	—	—	—
Individual variations,	7c	5c	7c	5c

Total variation, 1.2 vibration = 8c = $\frac{1}{25}$ tone.

The variations of the individual reproductions were almost identical with those of Series I–III, viz., not below 5c nor over 7c (the fourth of Series I was but 3c, and the first of I and the fifth of II were 4c); and the total variation of the whole ten minutes was for the third time 8c = $\frac{1}{25}$ tone (Series III, 6c). Moreover, in each reproduction the note was at its lowest at first and its highest at last. But in the last two reproductions there was a decided lapse just before the end in the continuity of the rise. Within the ten second spaces the rate of the beats varied slightly, as before, from these figures, now hurrying and now slackening.

Taking up the tests again three days later, I took an inscription of the harmonium c′ on Cylinder F, the rate of revolution being made 192 per minute for comparison with E at 184. F proved practically worthless, the tone being irregular throughout and changing toward the end through a whole minor third. From this whole series of tests of rapidity I concluded that the limits beyond which the performance of the instrument would begin to show marked deterioration might be set at 155 and 180 revolutions per minute.

Cylinder B (176, 170+) had then been taken, and was used in my tests at very nearly the most favorable possible rapidity. To finish these tests of the phonograph by the method of beats, I made one more series (quintuple) with B, obtaining the following figures: —

SERIES V. Cylinder B (inscription 176, reproduction 168 revs.)

32	31	32	24	26
32	24	32	26	32
30	28	28	28	29
32	28	28	30	29
26	32	?	?	28
—	—	—	—	—
4c	5c	3c	4c	4c

Total variation of entire series, 1.2 vibrations = 8c = $\frac{1}{25}$ tone.

The individual variations averaged even less than any yet noted; and the total variation during a performance of about twelve minutes was exactly what it had been in three out of the four previous series, viz., 8c, or the 25th of a tone. The ephemeral hurrying and slowing of the beats somewhat beyond the limits expressed in the figures also reappeared occasionally. But this series differed from the preceding, in that the progressive sharping had given place to an irregular variation. At the same time I noticed that in the last quarter of the cylinder the element of tone had entirely disappeared in a scraping noise. With this series I ended my tests of the phonograph.

In the earlier reproductions of Cylinder B, if we take μ as the initial tone, we have Δ^{μ}_{ν} increasing to a maximum of $\frac{1}{40}$ of a tone as we take ν farther along in the reproduction. This suggests looking for conditions affecting the rate of the instrument, which progressively change from beginning to end of a cylinder, and which, if present in both inscription and reproduction, are more effective in the one case than in the other. The wax cylinder which is used in the phonograph is carried on one end of a shaft of about two and one half times its length. At the beginning of an inscription the needle is approx-

imately equidistant from the two bearings of the shaft, and whatever addition to the friction at these points is due to it may be supposed equally distributed between them. At the close of an inscription the needle is very near, almost over the right-hand bearing, and whatever friction it causes may be conceived as mainly concentrated at this point. Let it be admitted that this gradually increasing disparity between the amount of friction at the two bearings would cause a gradual slowing of the cylinder as the needle went on in its course; this supposed change in conditions of friction, and consequently this slowing, would take place both in inscription and reproduction: but if it were any less in amount in the latter case, the note would tend to rise in pitch as the reproduction went on. For a source of constant pitch imparts to the phonograph diaphragm equal numbers of impulses in equal times; if now the cylinder takes a longer time to move through an equal arc, as the needle advances over it the indentations it makes will be closer together in later than in earlier positions of its path. In the reproduction, on the supposition that the change of place of the needle caused no slowing at all, — that is, that a given arc of the cylinder passed under it in exactly the same time wherever it was, — since later indentations are closer together than earlier ones, the impulses they communicate to the diaphragm would be more and more rapid as the reproduction advanced. What went in a constant tone would emerge a gradually rising one. But a similar effect would be produced even supposing the reproducing needle retarded the cylinder somewhat, so long as this retardation were less in amount than that of record, the sharping being less conspicuous as the friction of the reproducing needle were greater. Now the inscribing needle is a plough (that is, cuts a furrow through the wax) and the reproducing needle is a harrow (that is, is dragged through this furrow), and the amount of resistance made by the former to the turning of the cylinder must be much greater than that made by the latter. Hence we may assume that the amount of slowing which takes place as the needle advances on the cylinder is much greater in inscription than in reproduction. It is the difference, we may therefore conclude, between these two retardations that appears as the minute upward movement several times observed in the note of Cylinder B.

The fact that this progressive change disappeared in the last trial of Cylinder B is perhaps not incompatible with this hypothesis of its origin. For we can interpret the preponderance of noise in this reproduction as a sign of an increase of friction between the reproducing needle and the cylinder. The needle then possessed a greater power than at first to retard the movement of the cylinder; and, as we have seen, if it possesses the same as that of the needle

of inscription, the note should become entirely constant. Nor is the fact that the sharping several times disappeared in Cylinder E (inscription rate 184, reproduction rate about 175) irreconcilable with the hypothesis; for with an increased momentum the mechanism may be supposed to grow less sensitive to the delicate changes in conditions of friction involved in the movement of the needles.

As to the hurrying and slowing of the beats within the ten second spaces, it does not seem improbable that these changes may have been mainly due to very small variations in the harmonium note which was the basis of the test, reflecting the intermittent character of the supply of air from the bellows of the instrument.

As the result of this inquiry by the method of beats into the distortion of an interval sequence in phonographic reproduction, we reach the following conclusions. With a storage battery of the kind now commonly used with the instrument, which has (*a*) not been too long used nor too long idle; in the reproduction (*b*) at from 150 to 180 revolutions per minute of (*c*) a fresh inscription made (*d*) within the same limits of speed, the phonographic distortion of interval, Δ^{μ}_{ν}, will in general, as the component tones are taken farther apart in the inscribed sequence, gradually increase from an inappreciable amount to about 5c, or the fortieth part of a tone, this aberration taking the form of a sharping or heightening of the later tone. Further, in immediately successive reproductions of an inscribed music, corresponding tones will be apt to be given at least four or five times to within a smaller interval still, often the hundredth part of a tone or less; the total range through which the performances shift in pitch meanwhile not exceeding in general the twenty-fifth part of a tone.

As a cylinder is more used, the aberration, Δ^{μ}_{ν}, within individual performances ceases to be progressive without increasing in amount, this truly wonderful fidelity of reproduction continuing as long as the inscription is audible at all.

At rates either in inscription or reproduction beyond these limits the aberration will be greater, increasing as they are farther transcended. The aberration will also in general be greater, and sometimes markedly

so with batteries which have been charged a number of days, even when little used. Thus with Battery 1, after disuse of ten days, the note of Cylinder B was given in general with about the customary heightening of one fortieth of a tone, excepting for one or two marked deviations in pitch, generally ephemeral in each reproduction. With Battery 2, which was not used until a month after charging, the reproduction of B varied continuously through fractions of a tone large enough to be audible. With Battery 3, also unused until a month after charging, while the variation could not in general be detected by the ear, it was sometimes as much as a quarter of a tone, in other reproductions being almost zero. Battery 4 gave with Cylinder B a note constant to within the customary fortieth of a tone, both when first used and after an interim of three days.

As an apparatus for the reproduction of textures of interval, the phonograph may fairly be called an instrument of precision. The tests indicate that under proper conditions, as notes are taken farther apart in an inscribed sequence, the distortion of the interval they form gradually increases from zero to a maximum of about a fortieth of a tone, which is generally reached only when they approach the extremes of a complete inscription. If, as may plausibly be claimed, such a distortion would always be either too small or too long in emerging to be recognized even by the ears of a Mozart, the phonograph is a practically perfect means of reproducing the major elements of musical form.

3. *Behavior of the phonograph during the record and study of this music*

The application of these data to our ultimate inquiry, viz., whether these notations record observations of the same set of facts of interval as were presented in the original performances, involves the question as to the constancy of rotation of the phonograph cylinder during both the inscription and the repeated reproduction of this music.

The same phonograph was used in both these processes. Dr. Fewkes took with him from Kansas City, and employed at the Pueblo for taking all these songs, a single storage battery of 150 amperes. It may have been in use in all three or four hours, a fifth or sixth part of the time

during which such a battery would in general be available; but this was a number of days after it had been charged. During the above tests the reproduction by stale batteries of an inscription (Cylinder B), giving with fresh batteries a note of the standard constancy, in one case (Battery 4, after considerable use and three days' idleness) reached the standard excellence; in another case (Battery 3, charged a month) either reached it or approximated ($\frac{1}{14}$ tone) to it; in a third case (Battery 1, after much use and ten days' idleness) approximated to the standard, excepting for one or two marked deviations of pitch in each reproduction; and in a fourth case (Battery 2, charged a month) gave a note varying continuously in long waves covering minute fractions of a tone. Judging from these data, although the revolution of the cylinder during the performances at the Pueblo may possibly have reached the standard constancy, more probably it exhibited a greater variation, either a marked one, during one or two short passages only of inscriptions, or a gradual and inconsiderable one throughout entire records.

The time required for noting these melodies by the method I employed (comparison of each note with near semitones of the harmonium) I found in general about a hundred-fold that taken up by their reproduction at approximately the same pitch. Nevertheless, so far as I was able to judge, the rate of the instrument either remained or was kept by adjustment of the electrical supply constant to within a ratio equivalent to an interval of about a tenth of a tone during the whole examination of each song; and during that of the individual phrases of the melodies either exhibited no change or a change through a much smaller ratio. It is to be noted that the sharping shown by the method of beats to take place in the course of an individual reproduction of a fresh record involves and, as it seems likely, is due to the transfer of the needle from one end of the cylinder to the other. We cannot therefore argue from this to a variation of a similar amount in every two or three minutes of a reproduction under examination, for during this time the needle has changed its position but little.

The notes I made as to the changes of rate of the phonograph during the work of examining these songs are in detail as follows: —

BATTERY 5 (150 AMPERES)

July 25. I began the notation of the songs, expecting to assure myself of the constancy of the phonograph by the method I had employed in studying the Chinese melodies before mentioned; viz., by returning every few minutes to some conspicuous note at the beginning of the record, to see whether I should be tempted to give it a different notation from that already chosen. I carried out this plan without making any notes of the results during this day's work, which consisted in the notation of Snake Songs Nos. 1 and 2.

July 26. I wrote down Snake Song No. 3, and made the following note of the running of the instrument. "To write this out took over an hour, and yet in going back to the initial note I could detect no change from the written pitch."

The ratio of the numbers of revolutions made by the cylinder in a given time, in two reproductions of tone from the same inscription, is that of the vibration numbers of the two tones produced. We may express this by saying that the ratio of any two numbers of revolutions per minute, executed by the cylinder at different times, gives the interval by which the pitch of the phonograph differs in the two cases.

The counting of the revolutions of the cylinder is conveniently effected by holding the finger lightly against a screw-head that projects from about the middle of the axis. The number of touches received in this way, during the time that elapses before the second hand of a watch passes again beyond the spot in its dial where we count the first one, exceeds by one the number of complete revolutions made by the cylinder in a minute. Although the point from which I began to count was always one of the ten second marks on the dial, I took the precaution to wait until it seemed to me that a touch was closely synchronous with the tick made by the watch (marking each .2″) as it crossed such a mark. I found myself in practice estimating the fraction of a revolution often seeming to take place between the last touch and the tick of the watch that next took the hand over the initial ten second mark, either as a half revolution (e. g. 170.5) or as less than a whole revolution (e. g. 171−) or as not quite a half (e. g. 170+). Even with these efforts at exactness, the probable error of such estimates of the speed of the instrument might easily be half a revolution or more. Assuming it at half a revolution, the error may be in each case either by excess or by default. But it is only when it happens

to be by default for the larger number, and by excess for the smaller, that it will lead to any material underestimate (by one revolution) of the interval by which the phonograph has varied. In general, we may assume the true interval of the change will little if at all exceed the ratio found by this method.

July 28. In studying Snake Song No. 4 this morning I obtained a speed of delivery about the same as that of Song 3 by raising the regulator screw until the phonograph made 168 revolutions. I note, "When nearly through I went back and found the initial note of the song still as written. On coming back to work in the afternoon I found the rate very close to 169. This sharping through about the interval $\frac{169}{168}$ or 10c ($=\frac{1}{20}$ tone) I noted still left the initial note of the piece as written, nearer c than $c^{\#}$."

July 29, 5.10 P. M. The screw having remained unchanged since the day before, the instrument made 168 revolutions. I thereupon wrote down Snake Song No. 6.

July 30, 11 A. M. The screw having remained untouched, the instrument began at 167 revolutions. To prove my work on Song No. 6 I then adjusted the screw so that the instrument made 168 revolutions, and found only one pianissimo pitch toward the end and two rests that needed a slightly changed notation. I then wrote down Song No. 8 at 167 revolutions.

July 31, 11 A. M. On taking up this song again this morning to prove my work of yesterday, I found the instrument running at 167. At 11.53 the rate was 166+. Another count immediately afterward made it 167. At 12.42, still 167. In the afternoon I wrote down Malo-katcina by Kano at this rate.

August 2, 3.45 P. M. The screw having remained untouched, I found the rate 167+; in a second count, 167. At this rate I noted Malo-katcina by Masi-umtiwa.

August 3, 12.15 P. M. After cleaning the instrument without moving the screw, the rate was 167+. A second count gave 167+ again; and at this rate I began to note the Song Ċoyóhim-katcina. At the end of an hour the rate was 168. On returning to work at 4 P. M. the rate was 169, and the change had, I found, perceptibly altered the pitch of the song, the opening note of which I should have now written g+ instead of g. In continuing the work I reduced the rate to 167 by an adjustment of the screw. At the end of two hours (5.55 P. M.) I found it again 169, and again reduced it.

August 4, 11.45 A. M. The instrument began at 166, but conceiving that its variation of the day before, though slight, might indicate that Battery 5 was becoming exhausted, I sent for another.

BATTERY 6 (150 AMPERES)

August 5, 9.45 A. M. I adjusted the instrument to 167 revolutions, and a few minutes later on another count found the rate the same. During the notation of Shiashtasha, Singer No. 1, the rate rose in perhaps half an hour to 169. I then set it at 168, and taking the rate at the end of each staff of the notation thereafter, no change whatever from this figure revealed itself.

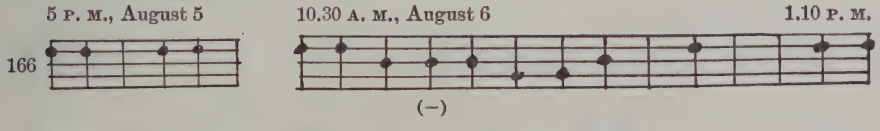
I concluded thenceforth to adopt this latter method of keeping track of the variations of the phonograph; viz., to examine and record its rate at the end of each staff of the notation. This amounted to taking note of it about every twelve or fifteen minutes, a period during which the experiments with the tuning-fork had indicated that under normal conditions the variation would not be apt to amount to more than about one twenty-fifth of a tone. I carried out this plan for all the rest of the songs, and have written the rates found in the notations at the points where they were taken. In the account which follows they are given diagrammatically. Each horizontal line signifies one revolution per minute, the equivalent (at these rates) of a twentieth of a tone. The spaces between the vertical lines signify periods generally something less than fifteen minutes.

SHIASHTASHA, SINGER NO. 1

On returning to work at 4.50 P. M. the rate was at first 166; a few minutes later, 167. At this rate I began the notation of Shiashtasha, Singer No. 2, but was unable to complete it that day.

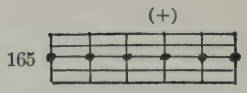
August 6, 10.25 A. M. The instrument began at 177 revolutions. To complete the notation of Shiashtasha, Singer No. 2, I set it at 167 and from this time until the work was finished, a period of two hours and a half, it ran continuously. The rates of the complete notation were as follows: —

SHIASHTASHA, SINGER NO. 2



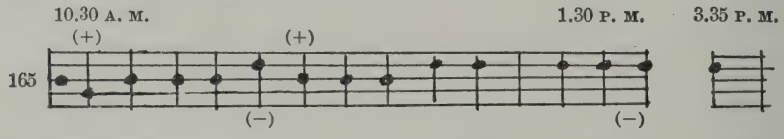
August 7, 10.30 A. M. The instrument began at 165, and of six counts made during the hour and a half required for noting Anoshkaey sung by Lesma but one (165+) varied at all from this figure.

ANOSHKAEY BY LESMA



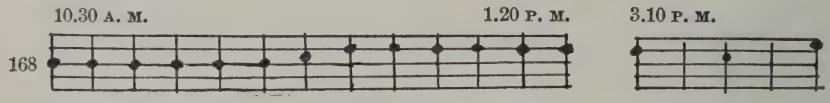
August 8, 10.30 A. M. After cleaning the instrument it still made 165 revolutions. At this rate I began Anoshkaey sung by Polakka, the instrument running continuously from 10.30 to 1.30 and again a short time in the afternoon to finish the song.

ANOSHKAEY BY POLAKKA



August 9, 10.07 A. M. The instrument began at 163. I set it at 166; three minutes later it was 167; fifteen minutes thereafter 168. I thereupon began the notation of Maihai-katcina, finishing it in the afternoon.

MAIHAI-KATCINA

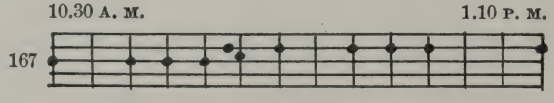


August 10, 10.15 A. M. This morning Battery 6 did not give a strong enough current to start the instrument. When set running by a push with the hand the revolutions were 166. I thereupon attached another battery I had kept on hand for such contingencies.

BATTERY 7 (75 AMPERES)

The phonograph began at 167 revolutions, the screw having been untouched. During the notation of Anonymous I the rates were as follows: —

ANONYMOUS I

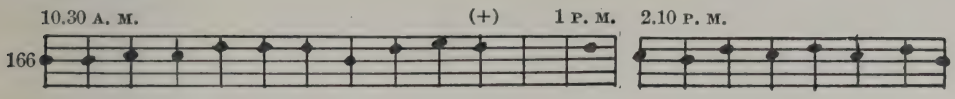


August 11, 10.30 A. M. Attached a fresh battery received in place of 6.

BATTERY 8 (150 AMPERES)

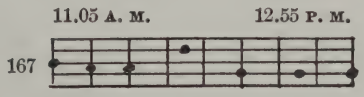
The screw being untouched, the rate was 166. The rates during the notation of Jakwaina were as follows: —

JAKWAINA

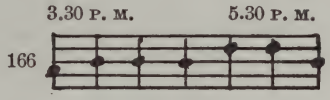


August 12, 10.35 A. M. After cleaning the phonograph the rate was 167. I then noted Haikaya, and in the afternoon Anonymous II.

HAIKAYA

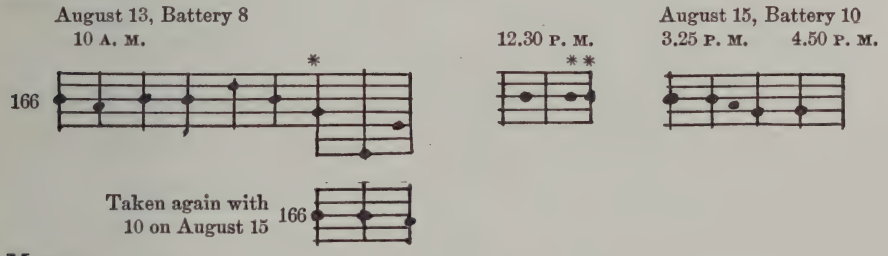


ANONYMOUS II

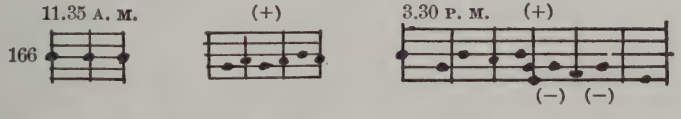


Up to this point in the notations the constancy of running of the phonograph had in general been little short of marvelous. Owing to a slight accident to the instrument, which I did not at once discover, the notation of the remaining two songs within the limits of variation which I had set myself (one tenth tone) was accomplished with difficulty.[1] The details of rate are as follows, the stars in Sumýacoli referring to points so designated in the notations.

SUMÝACOLI



MANA



The notation of the songs was now complete, but I used the phonograph during three or four more days in a revision of a few doubtful points, and in making versions by ear of some of the songs I had not yet listened to for this

[1] An inspector from the phonograph company found "top governor brush with one wire above the others, not allowing the governor brush and the governor flange to make a good contact, which caused an irregularity in the speed." This had come about in cleaning the phonograph.

purpose. During this time I used three fresh batteries, the rate of the instrument being somewhat more constant than it had been during the notation of Sumýacoli and Mana.

To sum up: as to the constancy of the phonograph during the inscription of these melodies in Arizona, and during the subsequent use of these inscriptions for notation, the following conclusions may be drawn from the data gathered: —

In the inscriptions: possibly the standard constancy, but more probably either a continuous variation through ratios equivalent to audible fractions of a tone or an occasional ephemeral and marked aberration.

In the reproductions: no departure from constancy during any song equivalent to an interval of much more than one tenth of a tone, this change being in all cases spread over a number of notes, and generally over the greater part of the song.

From these conclusions the following inferences may be drawn as to the faithfulness to their original intervals of the reproductions from which these notations have been made: (*a*) distant segments of the reproduced performances may not infrequently have been displaced one upon another through an interval large enough to be reflected in a notation according to the method hereafter to be described; (*b*) within individual periods of the songs the distortion has probably in general been insufficient to affect the notations, although some may have contained one or two spots of more or less marked aberration. That is, for the most part, the notations of separate periods of the performances do not differ from what they would have been were the phonograph an absolutely perfect instrument.

Returning finally to the distinction touched upon in section 1, it may be claimed that notations of primitive performances by the present method are for the first time records of their facts of form, a little, and yet but very little, blurred and distorted by the medium through which they become accessible to study.

4. Method and symbolism of the notations

Like the records of Zuñi music, these which follow are the result of an attempt to judge the tones delivered by the phonograph by means of the sense for difference of pitch alone, without aid from the sense of interval. My aim has been to make a separate estimate of the pitch of each individual note of each performance, through its comparison with one or more of the series of tones at intervals of a tempered semitone, or 100 cents, given in the notes of an ordinary harmonium. This comparison was made, as before, by silencing the phonograph the moment the note to be judged had been reached, and immediately thereafter sounding a harmonium note. During the work of writing down the Zuñi melodies, this comparison always had one or other of two results: either there was one harmonium note which at once impressed me as the nearest, or what struck me was the divergence of the note of the song from any harmonium note, even the one which finally appeared nearer than others. The lines and spaces of the common musical staff used with one accidental afforded in all cases a sign for the nearest harmonium semitone, a stroke being written above this when the heard note was markedly sharper, and below it when markedly flatter.

The present notations were begun with much more confidence in the phonograph, and after much more practice in the delicate comparisons of pitch involved in their method. Neverthless, the voice of the singer of the snake chants being somewhat harsh and obscure, and the phonograph not having yet shown its great constancy through long periods, it did not occur to me in the first eight songs of the collection to attempt anything more than the dichotomy of the comparisons made also in writing the Zuñi melodies. But in beginning Çoyóhim-katcina, which was sung in a bold and clear voice, I decided to attempt another distinction, by dividing the notes noticeably nearest to some one harmonium semitone into those immediately recognizable as different therefrom and those which might be identified therewith. Later I found myself in practice dividing the latter class into those in satisfactory and those in unsatisfactory unison with semitones of the harmonium. The symbolism used in expressing these distinctions was a modification

of that employed in the Zuñi melodies, its application in the four cases of comparison being as follows:—

1. Whenever the reproduction was accepted without difficulty by the ear as a unison with one of the harmonium semitones, the note corresponding to the latter was written alone.

2. The sign (−) was used whenever the reproduction could by an effort, yet not without effort, be regarded as in unison with one of the harmonium semitones. In these instances I found it possible to make either one sound higher by simply choosing that it should. The sign was written under or over the note corresponding to the harmonium semitone in question, according as a fresh comparison without predetermined result after a few moments' rest made the reproduction above or below it.

3. The sign − was used whenever it was impossible either to regard the reproduction as a unison with any harmonium semitone or to regard it as nearest to any but one. The sign was written under or over the note corresponding to the nearest semitone, according as the reproduction sounded below or above this.

4. The sign = was used whenever there was doubt as to which of two adjacent harmonium semitones was the nearest to the reproduction. In these instances it proved possible to make either one sound nearer by simply choosing that it should. The sign was written with the note corresponding to that of the pair on the harmonium to which a fresh double comparison, after a few moments, without predetermined result, made the reproduction seem nearer, and over or under it according as the reproduction sounded above or below this.

The suggestion for such a symbolism is to be found in the use by Hauptmann and Helmholtz of a bar under or over the letter for a certain step in the diatonic scale, to indicate divergence from this step in the minute interval of the comma. Applied in notations of music, the device may be said to add others to the list of accidentals, which make of our European notation a symbolism partly natural and partly conventional. While the lines and spaces of the common musical staff represent up and down in pitch by higher and lower on the written

page, accidentals involve their representation by symbols on a level. Certainly in part, and not improbably as a whole, the above described development of the Zuñi symbolism is an extension of this conventional element in notation. Using the sign $<$ to indicate "lower than," the following judgments as to higher and lower are a part of the results of the comparisons above named:—

$$a^{\sharp} < \underline{b} < b < b < c.$$

It appears very probable from the same results that

$$a^{\sharp} < \underline{\underline{b}} < \underline{b} \quad \text{and} \quad \bar{b} < \bar{\bar{b}} < c,$$

and as far as the comparisons make any inferences possible about $(-)$ and the relation of $\underline{\ }$ to $\bar{\ }$ they are that

$$\underline{b} < \underset{(-)}{\underline{b}} < b < \overset{(-)}{\bar{b}} < \bar{b} \quad \text{and} \quad \bar{\bar{a}}^{\sharp} < \underline{\underline{b}}.$$

Taken altogether these judgments are as follows:—

$$a^{\sharp} < \overset{(-)}{a}^{\sharp} < \bar{a}^{\sharp} < \bar{\bar{a}}^{\sharp} < \underline{\underline{b}} < \underline{b} < \underset{(-)}{\underline{b}} < b.$$

Thus the judgments of higher and lower contained in and inferrible from the special symbolism which resulted from my endeavor to give the comparison of this music with the harmonium all reasonable exactness involves the recognition of seven distinctions of pitch to the semitone.

The notations made on this system of signs appeared upon a review of them impracticably complicated; and it seemed wiser to transcribe them upon another record which, while using, as the first had done, the customary notes and the customary signs of time, should dispense altogether with the conventional element commonly represented by accidentals, and present every distinction of above and below in pitch by higher and lower on the written page. To this end there was needed, besides a hypothesis as to the order of the symbols in pitch, an assumption restricting the meaning of the series to the steps of a definite subdivision of the semitone. The simplest subdivision, that of approximately equal intervals, was the one adopted. The following notations of performance are not, therefore, a simple record of observation;

but as they stand involve two theoretic elements, — interpretations of the original comparative observations first in terms of higher and lower in pitch, and second in terms of a scale of approximate fourteenths of a tone.

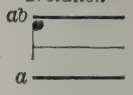
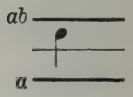
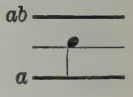
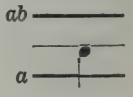
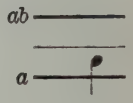
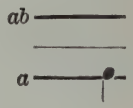
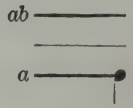
In the common notation of music, the sequence of lines and spaces taken from below upward has the significance of the diatonic series of intervals from low to high.[1] The separate systems of lines, or staves, are always fivefold, with extensions on occasion (leger lines), their diatonic meaning being indicated by writing at the left hand end of one of the lines the symbol (clef) for the step which that line signifies. The chromatic and enharmonic subdivisions of the diatonic order are left to be indicated by accidentals. For the expression of the much more minute scale of fourteenths of a tone made the basis of these records, without the employment of any accidentals, I have adopted the following modifications of the historical notation. Equal distances up and down in the page indicate equal intervals in the corresponding directions in pitch. Thus the equidistant horizontal lines, instead of indicating the sequence of every other diatonic step (and hence including sometimes a major third between adjacents and sometimes a minor third), indicate a sequence of equal intervals. Every other line is drawn heavier, these signifying the sequence of the tempered semitones (100c) incorporated in the notes of the harmonium. The intermediate lines represent the intermediate quarter tones: (50c). The number of lines in a connected system or staff is not limited. The symbol for the

[1] The diatonic series of intervals consists of alternate groups of two and three tones, separated by semitones. Since these terms tone and semitone are used with alternative meanings (harmonic and tempered), the common notation is an ambiguous system when smaller differences of pitch are taken into account. The scale with harmonic intervals differs as follows from that with tempered tones and semitones.

	c	d	e	f	g	a	b	c
	. T	. T	. S	. T	. T	. T	. S	.
Cents above (1) harmonic	0	204	386	498	702	884	1088	1200
(2) tempered	0	200	400	500	700	900	1100	1200
Interval of discrepancy in fractions of a tempered tone, about	0	$\frac{1}{50}$	$\frac{1}{14}$	$\frac{1}{100}$	$\frac{1}{100}$	$\frac{1}{12}$	$\frac{1}{17}$	0

note indicated by each of the heavier lines is written at its left hand end. In naming the harmonium notes the white keys are indicated by the usual lettering; c′ signifying the tone corresponding to about 268 vibrations per second, c″ its next higher octave, c its next lower octave, and C the octave below this. For the black keys, instead of either of the ordinary derivative names (flat or sharp), it seemed best to adopt a compound lettering, the sign for the white key next below preceding that for the white key next above; e. g. ab for the key commonly called either $a^{\sharp}$ or $b^{\flat}$. As in the like nomenclature of the mariner's compass this system might be applied further, the quarter tone between a and ab being called aab or a^2b, and that between ab and b, abb or ab^2.

The spaces, finally, between the horizontal lines, instead of being the width of the head of an ordinary musical note as in the common notation, are here made large enough to admit of its taking three easily distinguishable positions therein. These are positions (1) touching the lower boundary of the space only, (2) touching neither boundary, and (3) touching the upper boundary only. There is thus afforded for each of the fourteenths of a tone assumed as the steps in the scale of these notations a gradation of position easily distinguishable from every other; as appears in the following scheme of correspondence: —

Tone Observed	*Interpretation*	*Notation*
ab (−)	about $\frac{1}{14}$ tone (14c) below ab	
ab −	" $\frac{1}{7}$ tone (28c) "	
ab =	" $\frac{3}{14}$ tone (42c) "	
= a	" $\frac{3}{14}$ tone (42c) above a	
− a	" $\frac{1}{7}$ tone (28c) "	
(−) a	" $\frac{1}{14}$ tone (14c) "	
a	a	

The finer distinctions of pitch relation upon which this symbolism of fourteenths of a tone is based were made, as has been already stated, only in the ninth song and thereafter. In rewriting in the new form the records of the first eight songs, in which the single distinction of the Zuñi records was alone recognized, I have represented all the notes heard as markedly different from any harmonium semitone by the most easily distinguished among the intermediate signs, that for a seventh tone (28c) difference from them. In these songs this sign therefore represents a tone which may have been heard as further removed from the nearest semitone than the position of the sign indicates, e. g. (p. 48), the initial note in Snake Song No. 4 would have been noted in the same way at two phonograph rates representing an interval of $\frac{1}{20}$ tone.

The review of these performances after the work of notation showed them all to consist of more or fewer periods repeated more or less often in various rhythms. In the present notations these periods are lettered, and the points of division between them are indicated by perpendicular lines across the staff. These are, therefore, not bars in the ordinary sense, having no significance in accent or time. The accent of a note is here, as in the Zuñi melodies, indicated by a stroke above it. The possibilities of error in the matter of the recognition of alternations of intensity in a sequence of auditory sensations are as yet largely unexplored, although a beginning has been made at the inquiry. I am convinced they are considerable, and regard the accent marks of these notations as subject to much doubt in many places. The numbers frequently occurring in the notations denote the rate of revolution of the phonograph ascertained at that point in the work of writing down the performances.

The notation of a sequence of intervals by means of a system of signs for any fixed interval-order (as the common chromatic notation is a system of signs for a series of semitones, and the present notation is a system of signs for a series of fourteenths of a tone) must in general be more or less incorrect. It is like copying a tapestry with worsteds selected in advance without matching. The exceptional cases in which it may not present a garbled version of the sequence of intervals it aims to record will be those in which this happens to be such as might have been played on an instrument tuned to the series of intervals represented by the signs. When the system is a tempered one, such as the common chromatic notation or the present, the interval written may always be within a constant interval of the truth, viz., half of the unit interval of the system. The unit interval of the common chromatic symbolism being a semitone, the limit of error in the notation of the individual notes of musical sequence thereby is a quarter tone. For purposes of the general investigation of musical practice the common notation is therefore far from a refined instrument; just as with the alphabet of any language, but rude attempts can be made at recording the sounds of human speech in general. Nor has either sys-

tem of signs been devised for this larger purpose, but for the registration in the one case of certain special articulate elements, and in the other of certain musical forms.

The present modification of the common notation reduces this limit of error for individual notes from a quarter to the twenty-eighth part of a tone. In this symbolism the record of any interval of a sequence may then always be true to its original to within the fourteenth of a tone. This limiting error is about the interval of difference between the tempered thirds of our pianos and harmoniums and the pure intervals as they can be given on wind and stringed instruments. It might be, therefore, that characteristics of musical performance as delicate as the choice of pure in preference to tempered intervals should have their reflection in records of the present form.

5. *Value of the exacter notation of non-European music*

The attempt to follow the musical practice of non-European peoples with such minuteness must justify itself, either on the ground that accuracy of observation is a thing worthy to be aimed at for its own sake, or on the ground that in this branch of research such a degree of it has veritable value for purposes of theory. On the first point it may be remarked that if exact observation be itself part of science and not alone prerequisite thereto, intrinsic value is no more to be denied it in studies of melody than in reports of the changing configuration of an embryo or a sunspot. On the other hand, while the seeing little points, the making delicate distinctions, is indeed a differentia of excellent from inferior work in any department, these are little points with great bearings, distinctions important though delicate, else fineness would be littleness of mind, *Schärfe Spitzfindigkeit.* We must not simply be on the watch, *Spitzen zu finden,* but to discover hitherto overlooked edges of cleavage; to be sure these will in general be inconspicuous, else they would not have been neglected. In regard to non-European music, there are questions both interesting and reasonable, which are demonstrably unanswerable unless by the aid of more delicate observations than the common notation is adequate to record. Such observation has therefore theoretical warrant. One such

question is, whether a given primitive music recognizes in performance intervals other than those of the diatonic scale. That this question is not an unreasonable one appears from the fact that in music in regard to which we have other avenues of information than records of its products (e. g. theory, instrumental design), adiatonic intervals form a recognized element. That it is an unanswerable one in so far as we depend upon observations of performance taken down in the common notation appears from the facts (1) that whatever any given interval of a primitive performance may be in reality, when written in the chromatic symbolism it appears as one or another multiple of a (tempered) semitone, and (2) that every multiple of a (tempered) semitone is an interval of the (tempered) diatonic scale.

It may, indeed, be argued that adiatonic intervals are refinements of intonation which cannot reasonably be expected in the music of the unhistoric races. But this argument is based on premises the proof of each of which, if derived at all from musical practice, itself demands more exact observation than can be recorded in the common notation. For a given span in pitch will be a refinement of notation to a given performer only when another interval nearly like it is already known to him, and an impracticable refinement of intonation only when the two are to his musical sense hardly to be distinguished. The assertion, therefore, that all adiatonic intervals are impracticable refinements of intonation to primitive performers rests upon the assumptions (1) that they recognize diatonic intervals, and (2) that any interval intermediate in size to these will be too near its neighbors in the diatonic series to maintain a separate existence in the primitive fancy. The inquiry into the first of these assertions — whether diatonic intervals are recognized by primitive performers — is the same as the inquiry condemned on this assumption, viz., whether they recognize other than diatonic intervals. No evidence whatever, either upon this point or touching the ultra-diatonic refinement of the primitive musical sense, will be contributed by any observations of performance recorded solely in the common notation. Records of the nearest diatonic intervals to those which are actually formed by the tones of given textures have no bearing at all on the

question as to whether or no it is these diatonic intervals which are aimed at therein. Nor have records exhibiting only the distinctions of pitch which separate the diatonic intervals any bearing at all on the question as to how much smaller pitch distinctions are appreciable by the performers in question. To answer these queries from observations of musical practice, there is needed a system of notation which permits at once the registry of adiatonic intervals and of smaller pitch distinctions than the diatonic semitone. In truth, the opinion that the more natural music of the unhistoric races is always diatonic, adiatonic intervals being artificial products found among more civilized peoples only, may rightly at present be held in suspicion, seeing that the apparatus on which we are mainly dependent in the study of their music (the historical system of notation) is such as reveals diatonic intervals, and diatonic intervals only, in any textures of tone whatever to which it may be applied. The theoretic bearing of exacter observations than can be expressed in the common notation appears from these considerations to justify an effort like the present to record them.

6. *Trustworthiness of the present method*

The question as to the truth of the following notations to the actual course of tone of the phonographic performance from which they were made is the question as to the proportion of cases in which a note of the reproduction is represented by that sign in the notation which stands for the nearest fourteenth tone to that note. I myself feel great confidence that the great majority of those notes represented in the notations either as identical with or as about a seventh tone away from the harmonium semitones were in reality nearer these than any other steps of the fourteenth tone scale. In regard to the notes represented as a fourteenth tone from the semitones, while I have an equal confidence that the interval was generally much less than a seventh tone, I recognize that the fatigue involved in trying to hear what manner of difference this small discrepancy might be makes these judgments much more uncertain. In like manner I have a considerable though a less confidence that the notes appearing in the notations at three fourteenths distance from the harmonium semitones were in gen-

eral over a seventh tone away, but how often they may have been nearer the other of the two three-fourteenth notes than the one noted is a matter of some uncertainty. Besides the difficulty of comparing two closely similar pitch distances, there is another source of error peculiar to this latter class of cases, which suggested itself to me after the completion of Shiashtasha No. 2, and which I endeavored to guard against thereafter. The nature of these cases demands the repeated sounding of two adjacent harmonium semitones s′ and s″ with the phonograph note p′ to be judged; thus p′–s′, p′–s″. The semitone s′ being in general a clearer and distincter tone than the note p′, it might happen that the judgment of difference would be made between the after image of s′ and the new semitone s″ instead of between p′ and s.″ In this event the result of any individual double comparison would be an estimate of p′ as nearer that one of the adjacent semitones which happened to be sounded first. Although it may seem that error from this source would be most unlikely, I felt assured at the time that the danger was a real one. In both the (−) and the = class of comparisons I endeavored to eliminate the influence of fatigue by pausing after several trials, and then, before the familiarity with the notes to be judged had passed away, noting with a new stress of attention the first impression of the rested ear. But it was more difficult to get an opinion that would stand the test of repeated verification in the = class of comparison than in the (−) class. An indication of the final opinion was in both these instances sometimes given by the fact that, while as above noted it was possible by an act of will to realize in perception either of the two opposite possibilities about the relation of the notes under judgment, the resistance of the sensational material to this violence seemed greater in the one alternative than in the other.

I should perhaps hardly have attempted these minuter differentiations (−) and = of pitch relation at all had not a trial made in the course of the studies of Chinese performance above mentioned given me reason to think my ear might be trusted to report a phonographic reproduction according to this general method, in the main correctly to comparatively small fractions of a tone. Taking the mean of several

judgments of various repetitions of the same note in a melody given on the (specially tuned) harmonical, the intervals of the scale of this instrument were estimated in a majority of cases within a fourteenth tone of their actual span. (See the appendix to my paper on the Chinese Musical System.) These records were taken from the harmonium, with the aid of the tin horn commonly employed for the purpose, and had, therefore, the characteristic phonographic timbre resulting from the use of this form of receiver. The fact that I was nevertheless able to reach conclusions as to the intervals of the original performance which were so near the truth indicates that the influence of the change from the timbre of the original which occurs in good phonographic records upon judgment of the pitch of the notes involved may be but slight. In regard to the Hopi records, it is to be considered that they were not taken with the tin horn, but with the rubber mouthpiece used in records of speech, and that they sound like what one would suppose them from this fact to be, comparatively close approximations to the original timbre. An instance occurred in writing these songs in which the evidences are that the note judged was hardly at all nearer any other fourteenth tone than the one which we interpret as that chosen. During the examination of Çoyóhim-katcina in a reëstimate, at a different phonograph rate, of the initial note, originally judged in unison with the harmonium g, I found its proper representation to be $\bar{g}$. Assuming here a sharping from g through the interval represented by the two phonograph rates (which was calculated after the judgment), viz., about 20c, the note had risen to a point very nearly halfway between the tones assumed as the interpretation of the two signs (−) and −, the latter of which was chosen to indicate it.

7. *Deficiencies and improvements* Several sources of inaccuracy in, or uncertainty about, these notations which I noted or surmised during my work may here be mentioned. As is indicated by the perpetual recurrence of slurs in the records, these performances often have more the character of continuous streams of sound than of structures of discrete notes. On first hearing, many passages of the songs impressed me as a kind

of rhythmical howling, containing hardly more than the adumbration of interval. Any representation of such passages as pure sequences of notes will then in a measure be defective. Under these circumstances the pitch of the cardinal sounds of the performances, that is, the tone rests in distinction from tone movements, might often be judged somewhat differently, according as the phonograph was silenced a moment earlier or a moment later. I question whether the estimates of the pitch of the high sforzando notes are much to be relied upon unless when confirmed by repetition, and perhaps largely from this cause. The notations of quicker passages is for the like reason specially difficult and specially uncertain. Again, I seemed to find that, in the moment of silencing it, a phonograph note drops minimally in pitch. Yet any underestimate resulting from this cause would be apt, as far as one can see, to be a constant and therefore negligible error. Again, a blunder at which I once or twice caught myself was that of conceiving a clearly recognized difference between a harmonium note and one from the phonograph in the opposite to its actual sense; i. e. judging the wrong note to be the higher. Again, I found I had to keep to one attitude in using my apparatus; for much change in the position of the head with respect to the phonograph and the harmonium seemed to shift the pitch of the notes from both sources. Further, in order to eliminate the possible error from alterations in the intensity of the harmonium notes ($\frac{1}{25}$ tone from pp. to ff.), the effort had to be made to produce them at a constant (moderate) intensity. Upon the whole, numerous as are the sources of difficulty and error in an attempt to study musical performance carefully by the phonograph, it can hardly, I think, be denied that we are much nearer the raw material of the original sensation in notations made thus than in notations made by the naked ear.

But it may be questioned whether even this fact should suffice to commend the use of the phonograph to students of primitive music. For although we admit that the instrument repeats what it hears, and that what it repeats can be written down with an accuracy sufficient for scientific purposes, we may still impeach the character of the sequence of sound itself to which the cylinders were exposed. In an

attitude more or less constrained, perhaps without customary companionship in the song, before an awe-inspiring apparatus in rapid motion, a primitive musician can hardly be expected, it may be claimed, to give renditions at the command of a stranger which would be nearly enough like his natural performance to be worth studying carefully. Yet as far as my experience in taking phonographic records of non-European music goes, it tends to negative this critical claim. I venture to think it is in good measure founded upon a wrongful attribution to exotic peoples of our European habitudes of self-consciousness. A Kwakiutl Indian, whose performance before a phonograph I once heard through Dr. Boas's kindness, sheepish as was his air before beginning, when once buried in his song crooned away as simply and unhesitatingly as if he had been squatting on damp stones in a circle of his mates by a British Columbian river, instead of being seated in an office amid inquisitive Americans. Among Javanese and Syrians I have found, as I had before among Chinese, neither constraint nor indifference, but instead a very lively interest in and delight over the instrument, and great pride at being selected as spokesmen to this marvelously docile echo. Dr. Fewkes tells me that his experience in recording the performances of the Hopi was very similar. The Snake Chants had all to be repeated to the old priest who sang them; and not until they had passed his censorship, and he had breathed upon the cylinders, would he consent to give the records over. To give this skeptical surmise much weight in the valuation of the present notations it must be better substantiated than it is now. Nor would distrust of them involve a condemnation of the phonograph; for if it is possible to defeat a rogue's efforts to ruin his photograph for identification, it can hardly be impossible to aid a primitive performer's efforts to make a phonogram of his performance a true representative of the art it illustrates.

Possible improvements of method which suggested themselves in the course of writing down these performances are the following: Some entanglements with the interval sense might be avoided in the work of notation by such an adjustment of the phonograph mechanism as would permit the performance of the inscribed music backward. This device

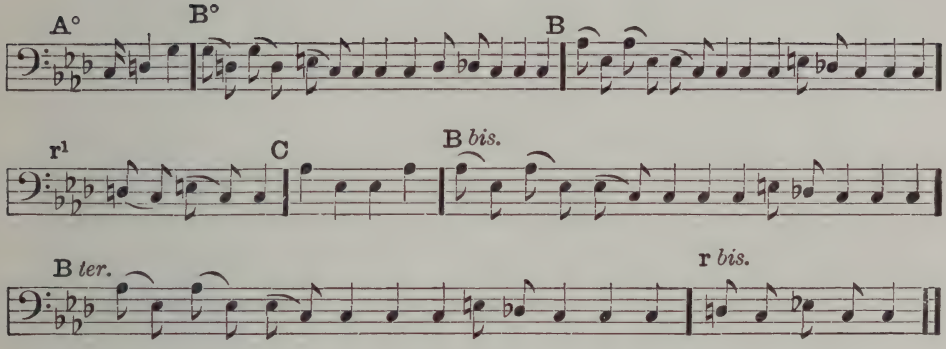
might result in some such defeat of our efforts to comprehend the presented sensation as supposably occurs when we look at a landscape with head inverted; and the tones composing the texture might emerge with the same clearness and delicacy that mark the tints of a view seen upside down. Again, phonographic records being permanent things within limits, the errors of one observer might be detected by the renotation of the same music by another. A method radically different from the present would be that of writing down the deliverances of the phonograph, not by ear, but by observing the rates of vibration of the diaphragm. The interpretation of a graphic record of the diaphragm movements would replace simple judgments of greater or less (tone distance) by actual measurement (in space), but if attempted to minute intervals would involve measuring waves to minute distances, a process both laborious and difficult and presenting its own possibilities of error.

In the recent studies of non-European music undertaken with the aid of the phonograph in the Psychologisches Institut of Professor Carl Stumpf of Berlin University, the instrument of comparison was the Appunn tonometer, in effect a harmonium of narrower range, with notes spaced much more closely (every few vibrations). In the more recent Stern variator, by Max Kohl of Chemnitz, a tone produced by a stream of air across the mouth of a metal bottle can be varied to a vibration or less by turning a crank. The use of this instrument would substitute a method of likeness for the method of difference heretofore employed. The variable tone would be adjusted to unison with the phonograph note and the vibration number read. The practicability and accuracy of such a device could be ascertained only by trial, but it would seem to promise a determination of phonographic sequences which for the purposes of the science of music could be called absolute.

III

NOTATIONS, DIAGRAMS, AND COMMENTS

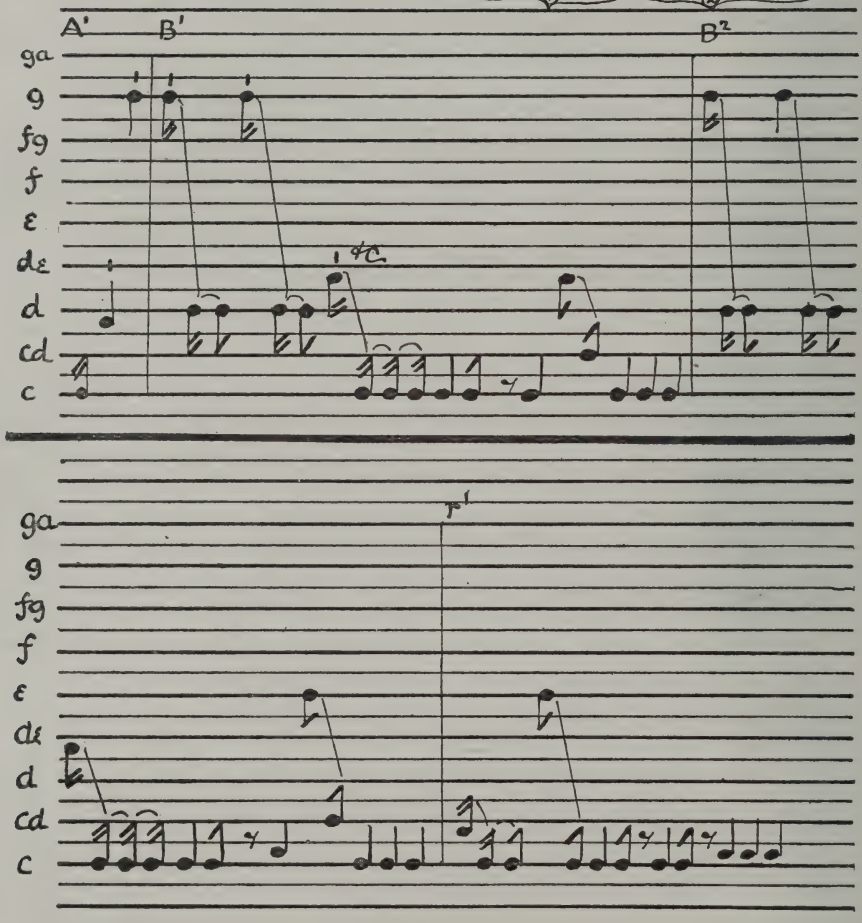
SNAKE SONG NO. 1

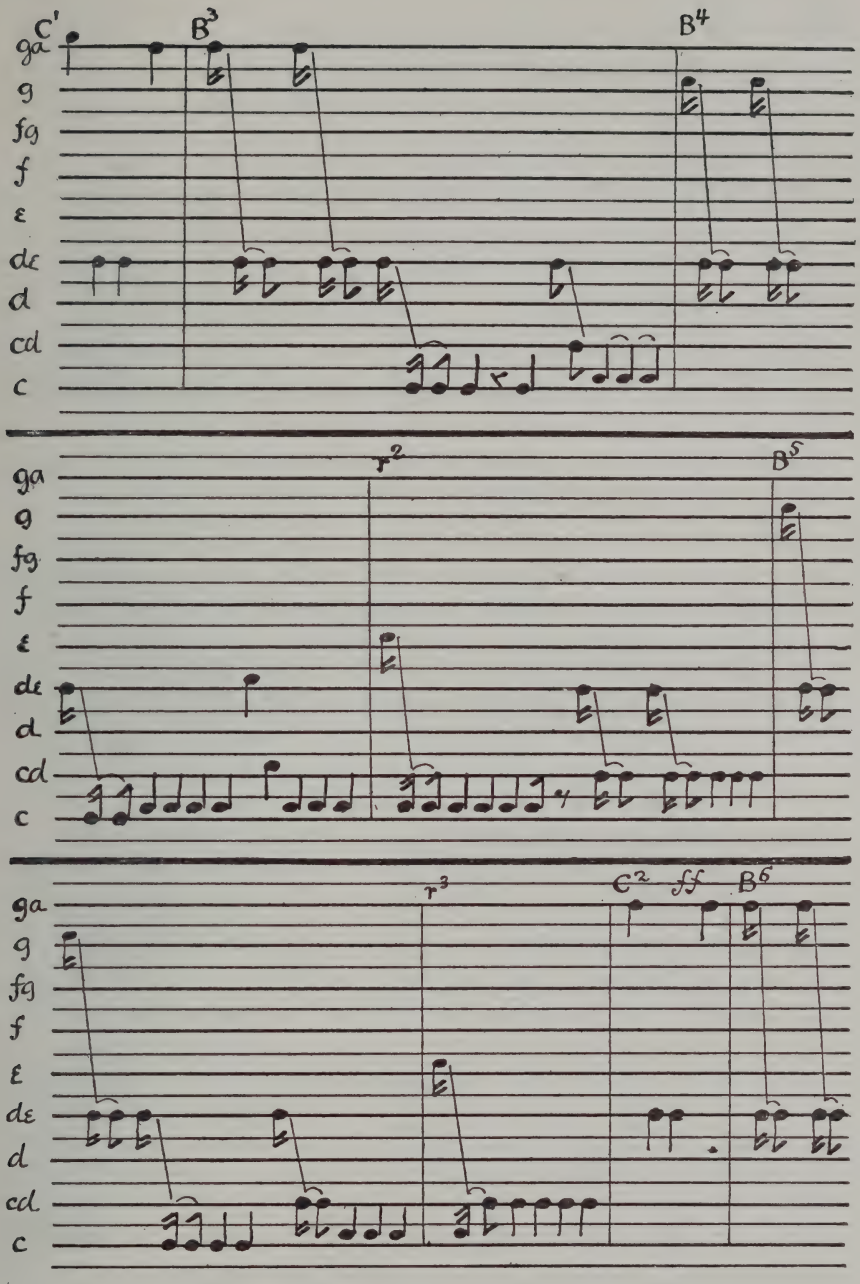


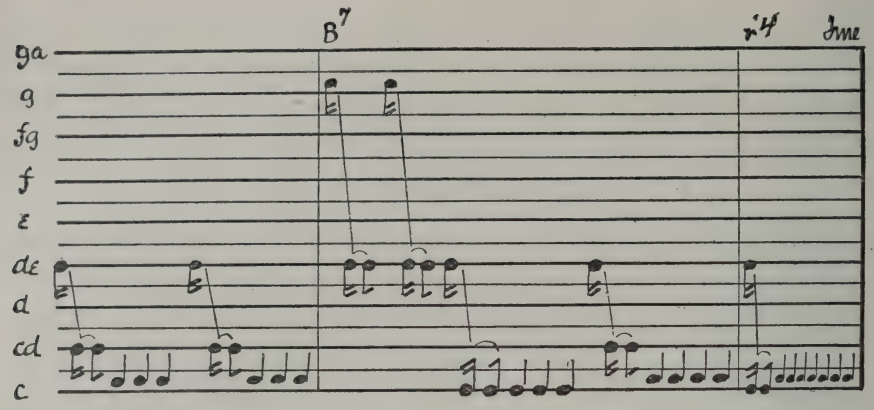
(I) SNAKE SONG No 1. CYLINDER XIV at 173 revs.

♩ = 110 . Accent on successive ♩. Scheme of Record

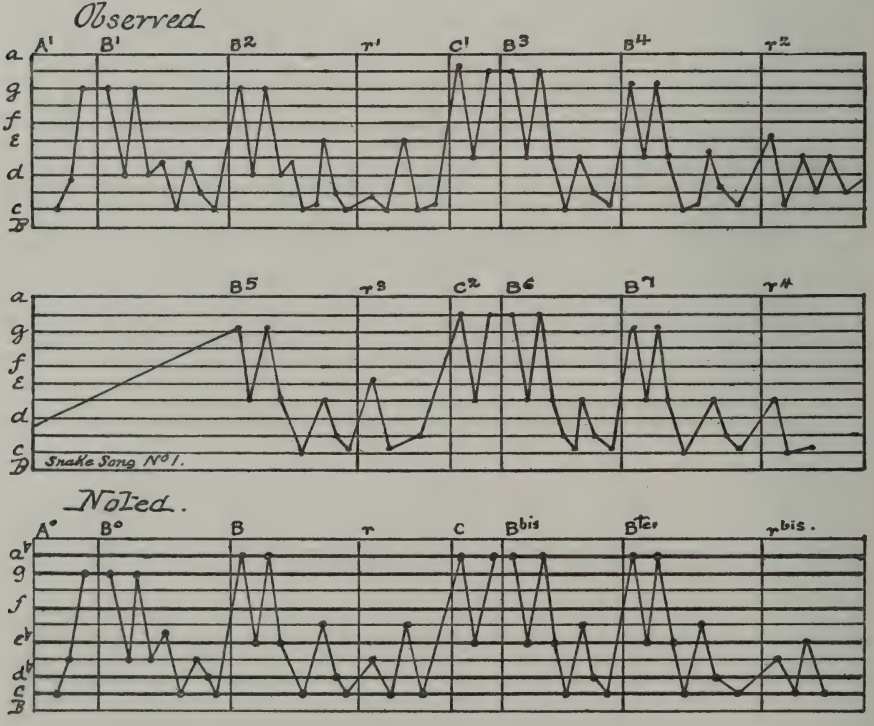
A' B' $B^2 r^1 C^1 B^3 B^4 r^2 B^5 r^3 C^2 B^6 B^7 r^4$




C¹
B³
B⁴
r²
B⁵
r³
C²
ff
B⁶
ga
g
fg
f
ε
dε
d
cd
c



COURSE OF TONE: SNAKE SONG NO. 1



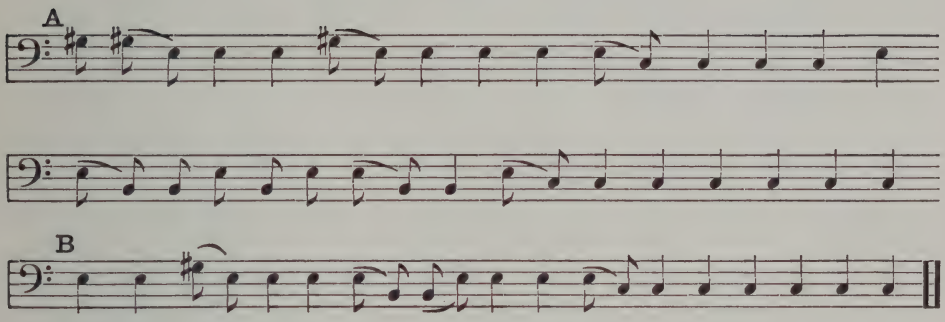
ARGUMENT. The partition of the base of the triad g–c produces a tritonus, g–cd, which is obviated by expansion of the triad to ga–c, revealed again by subsidence, again obviated, again revealed, and finally done away with by reintegration of the base.

THIS song consists of an introduction, A^1 B^1, followed by a complex rhythm of six segments, B^2 ——r^2, once repeated, B^5——r^4. The movement begins as a salient subminor triad, the main feature of the rhythm being the immediate change of this combination to a minor triad (sketched in B^2, carried out in the repetition B^5), which is successively augmented and reconstituted upon a basal note constant throughout except for an occasional and itself rhythmical sharping by a sixth tone. Simultaneously, in the salient thirds at the close of the B's, the basal note is duplicated, one representative sharing in the semitone rise of the interior note, and forming a tritonus with the summit note except during the sharping of this latter. In the r's before the augmented interval (also B^2 and r^2) the interior note is temporarily raised a semitone higher still.

This change of form is not properly modulation, since the basal note persists. It is a disaggregation of structure, in this case brought about and repaired in two steps. Out of the minor triad into which the subminor of the introduction immediately changes, the duplication of the basal note forms a tritonus. The original subminor triad supervenes and frees the texture of this unnatural interval. Upon the relaxation of the summit note the tritonus reappears, until in the final movement of the song in r^4 the two basal notes coalesce to replace the minor triad in which the rhythm began.

This rhythm passed unnoticed by the unaided ear, which recognized no fifths at all in the song proper, and went quite astray in grasping the r's. The result is inelastic and vapid, the musical point of the song being wholly missed. It is possible that in other renditions the same singer or others would betray other intentions within a recognized identity of musical structure. The notable feature of the present performance is the close repetition of a change in form which, to the scalar musical consciousness, appears fluid and lawless.

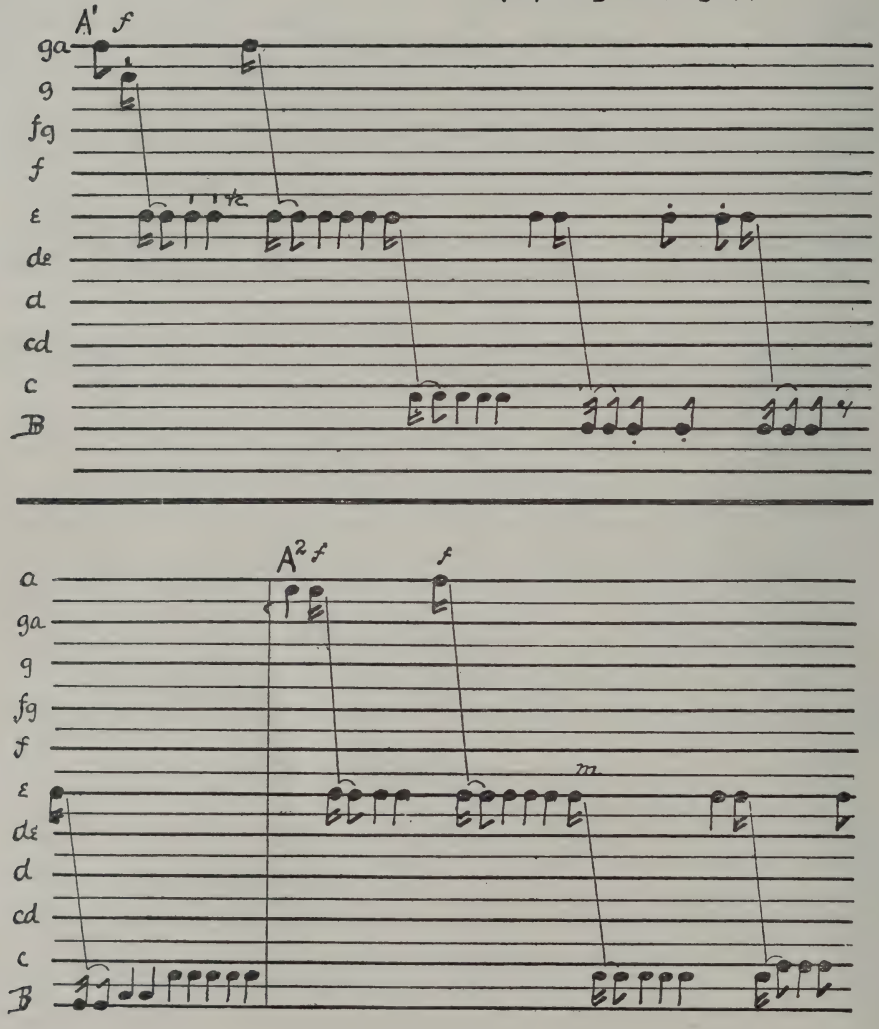
SNAKE SONG NO. 2

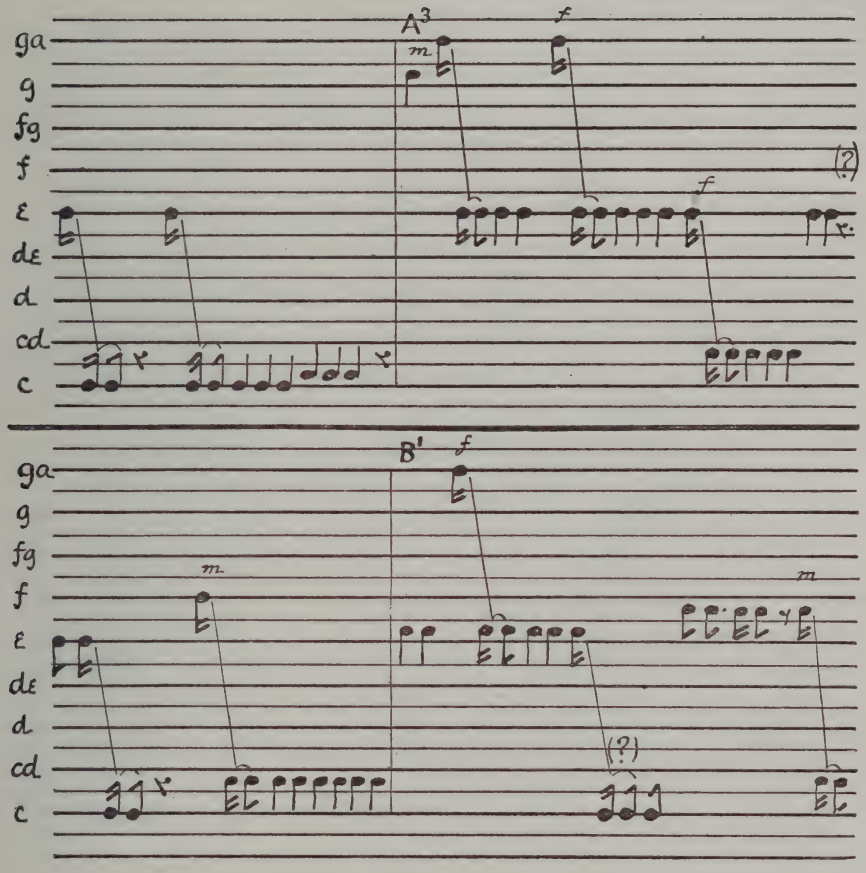


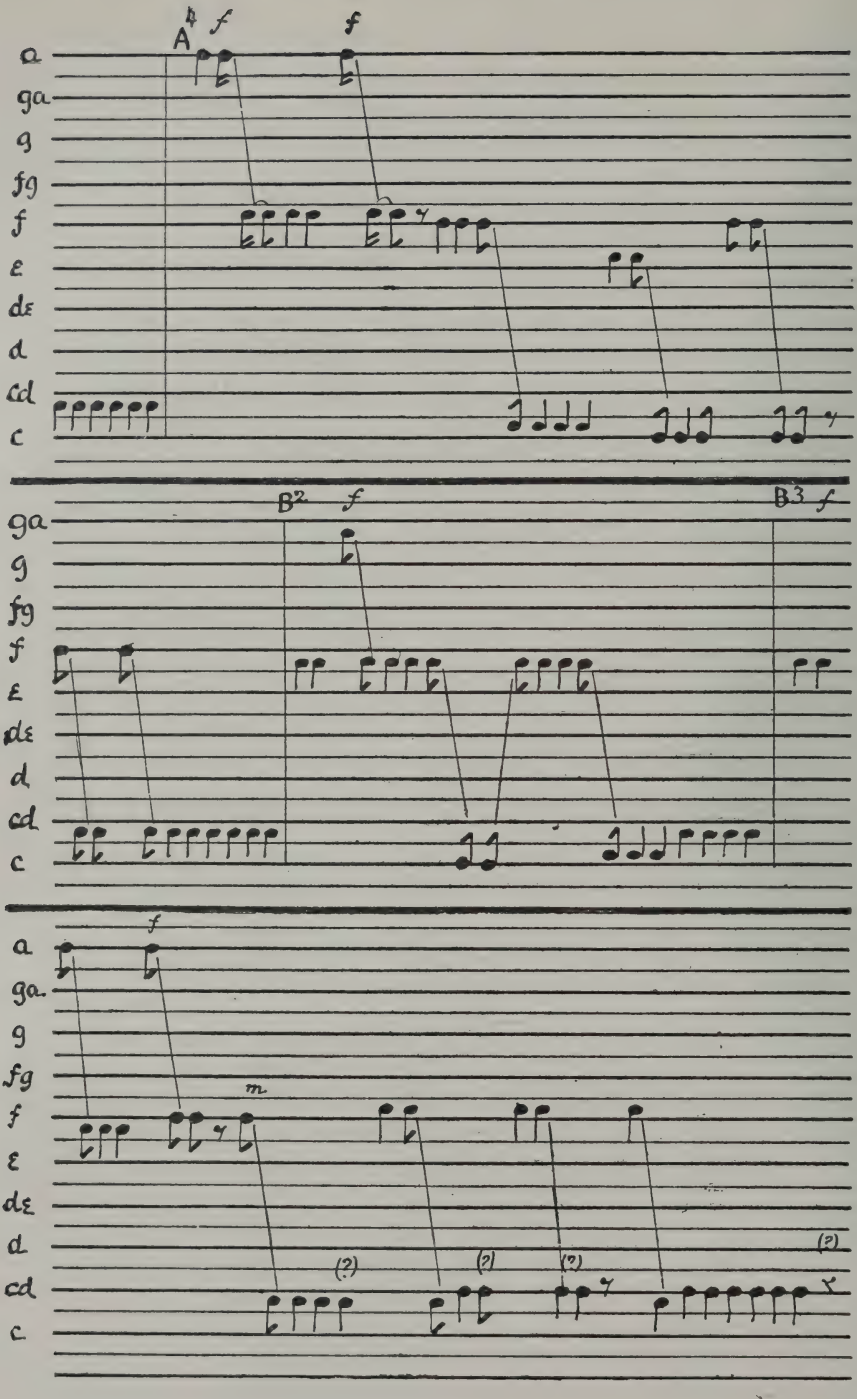
(II) SNAKE SONG N° 2 CYLINDER V. at 176 revs.

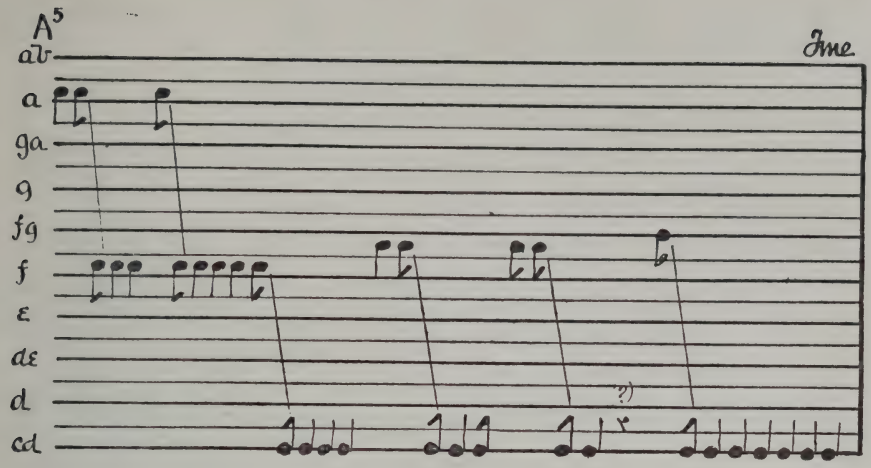
♩ = 106 Accent on successive ♩. Scheme of Record.

$A^1A^2A^3B^1A^4B^2B^3A^5$

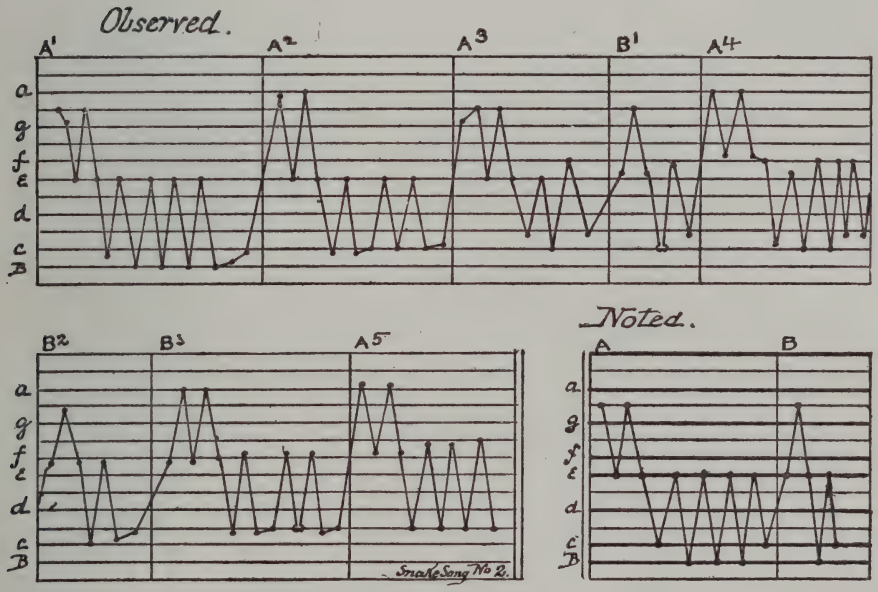



A3
m
f
f
(?)
B'
f
m
m
(?)
ga
g
fg
f
ε
dε
d
cd
c


A
B2
B3
(?)



COURSE OF TONE: SNAKE SONG NO. 2

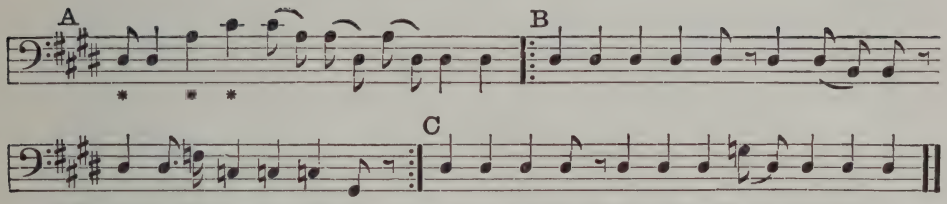


ARGUMENT. An augmented triad, ga–e–c, rises and falls about its axis, e, which then alternates with, and finally holds, a pitch a semitone higher, f; the triad rising until equally divided as at first, a–f–cd, whereupon the axis rises another semitone, to fg.

IN this song A is a downward sequence of two thirds, the lower repeated, and B a rehearsal of the same combination from the mediant instead of the summit. In both segments the lower interval tends rather to be the larger (sometimes a fourth), and the two seem executed each for itself, independently of the relation of their extremes. The movement may be described as a slow balloon-like play of augmented triads about an interior note held exactly constant halfway through the song, to be then alternated with a pitch a semitone higher, transferred to that pitch less closely held, and in the final segment shifted upward another semitone. The major augmented triad of A^1 (major third over fourth) becomes in A^2 minor (fourth over major third), in A^3 a minor triad, and in B^1 virtually a major triad. In A^4 at the higher level it becomes again the original major augmented triad; and, the lower interval being immediately shortened, the new base becomes the starting-point of the final upward shift in the interior note. This results from an expansion of the lower interval in A^5 like that in A^1, but opposite in sense.

While recognizing the non-diatonic character of this song, the unaided ear could not follow its serpentine elasticity of form, catching only this initial downward expansion which the phonograph shows to have had no cardinal importance in the melody.

SNAKE SONG NO. 3

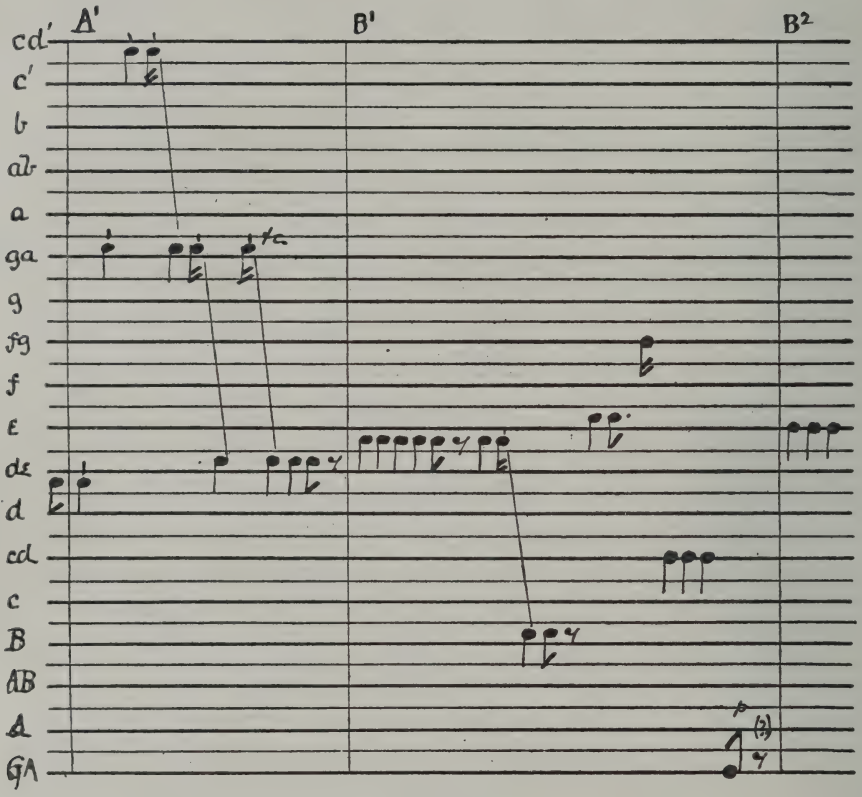


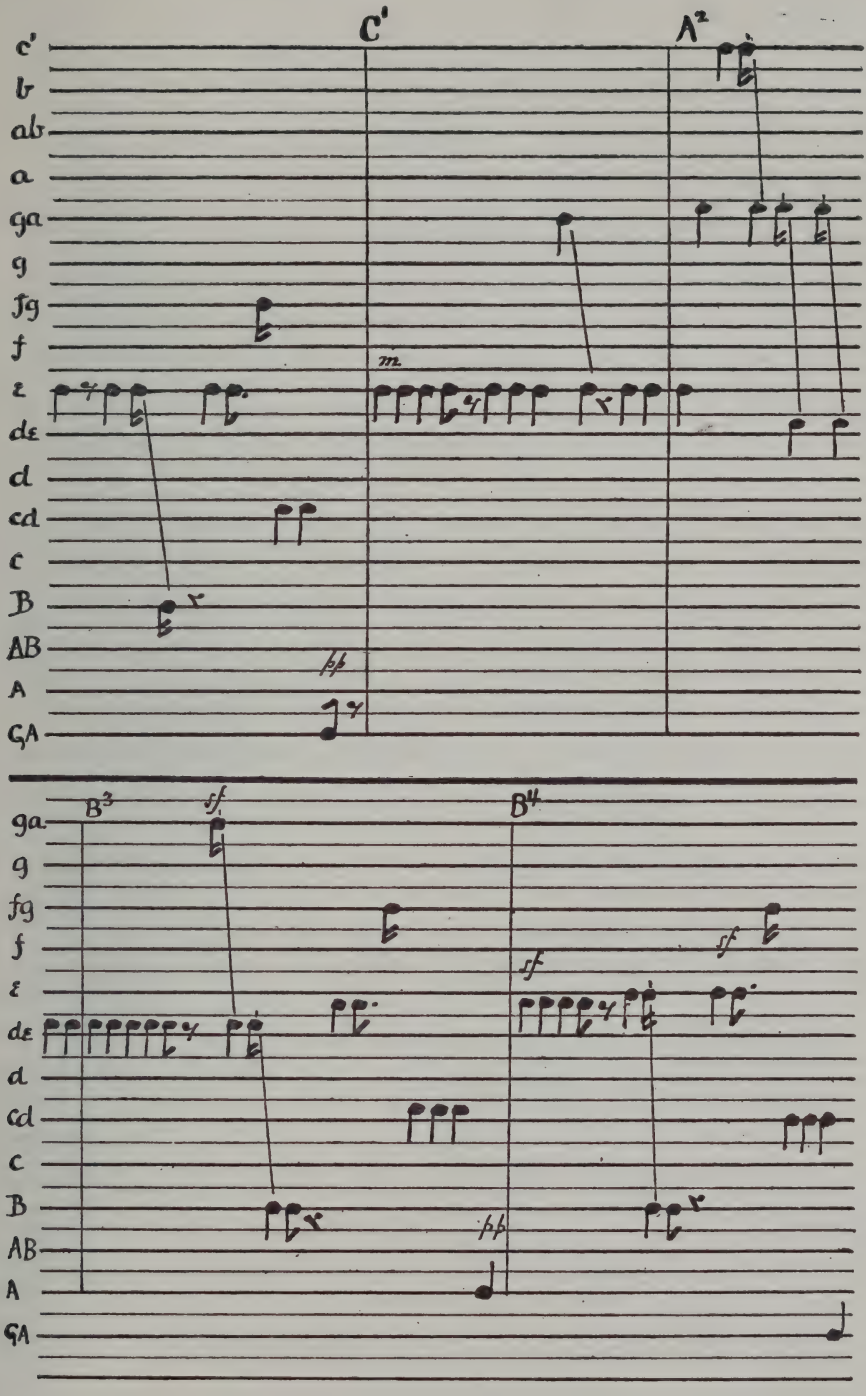
* The d♯ sometimes sounded like e: the a was uncertain in pitch and the c′♯ sometimes c′.

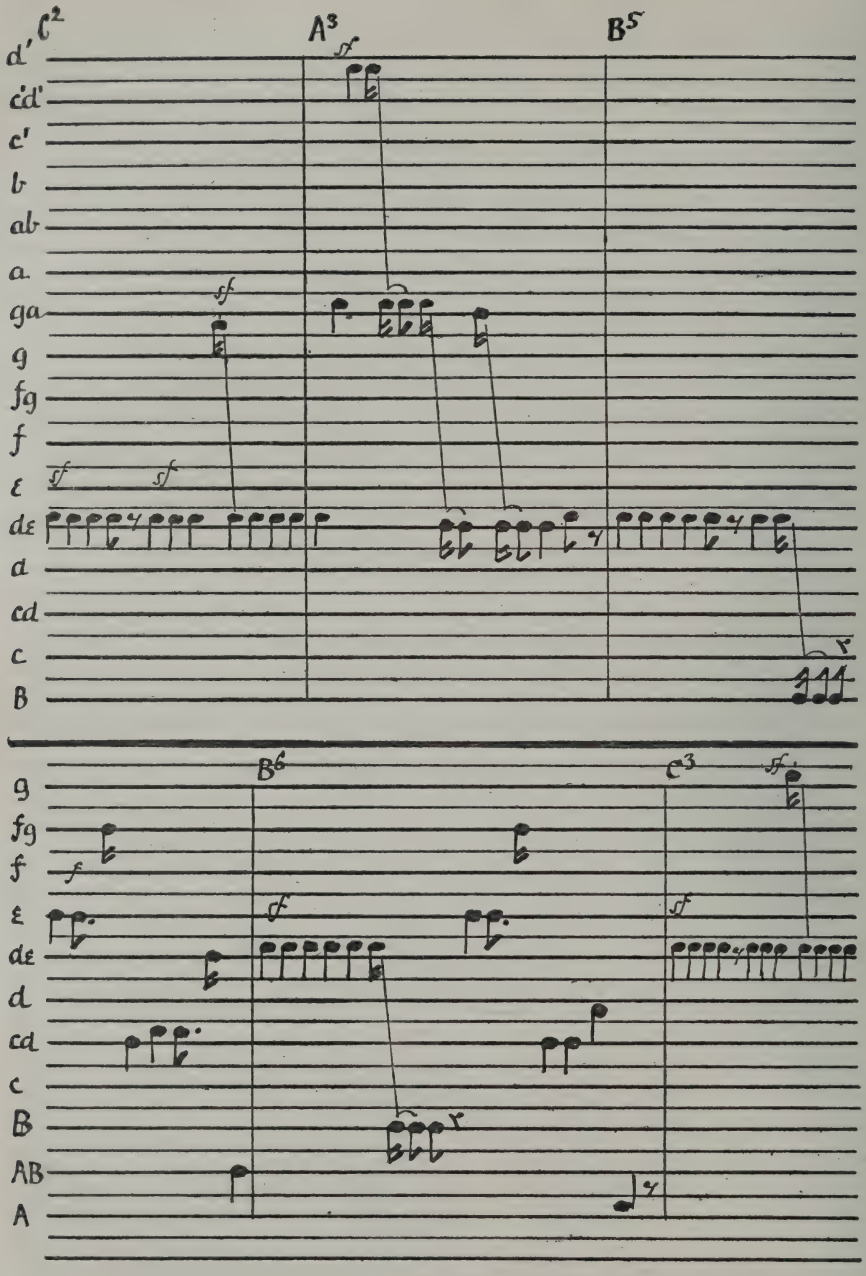
(III) SNAKE SONG Nº 3. CYLINDER XXIII at 170 revolutions

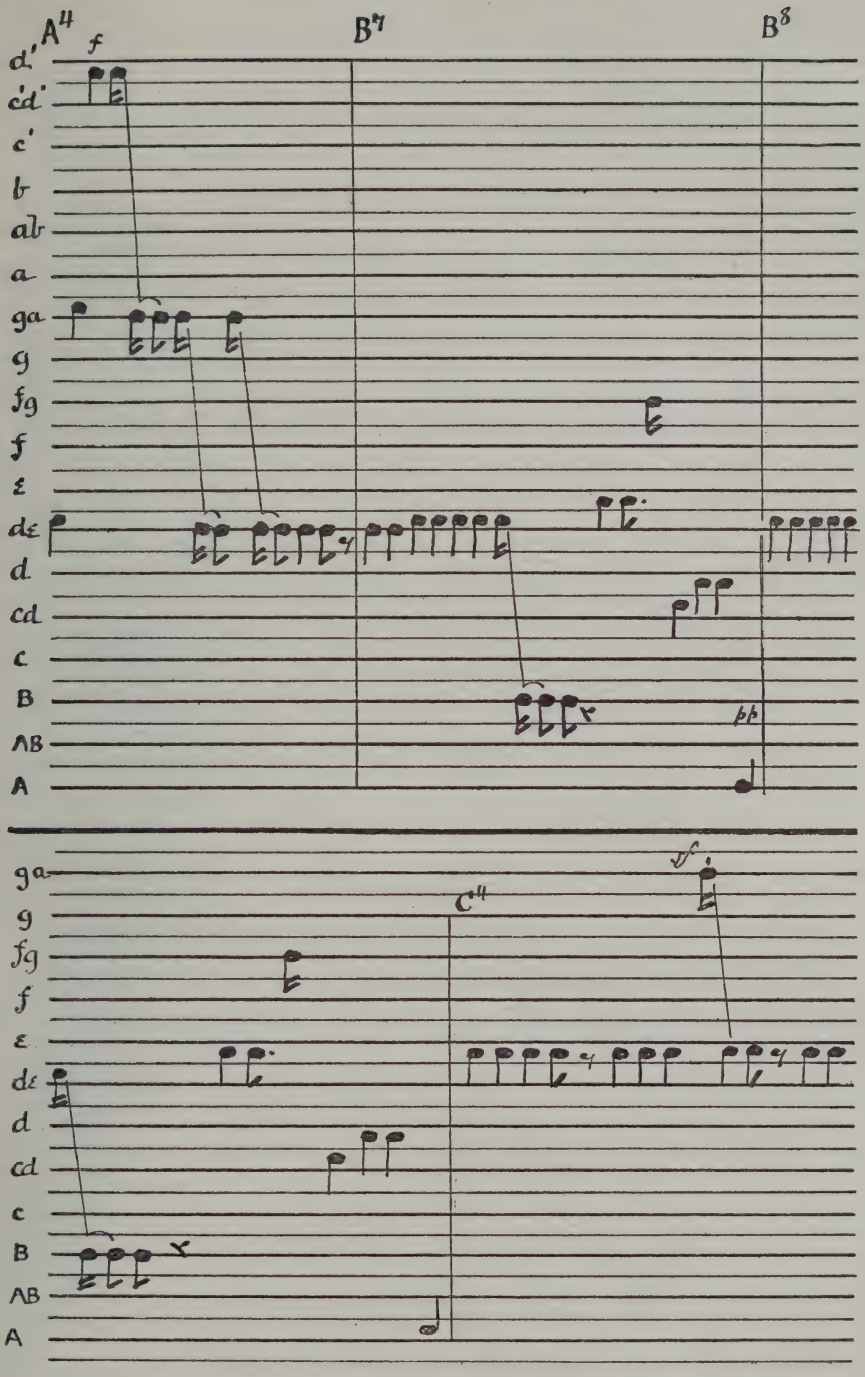
♩=110 Strongly accented on successive ♩

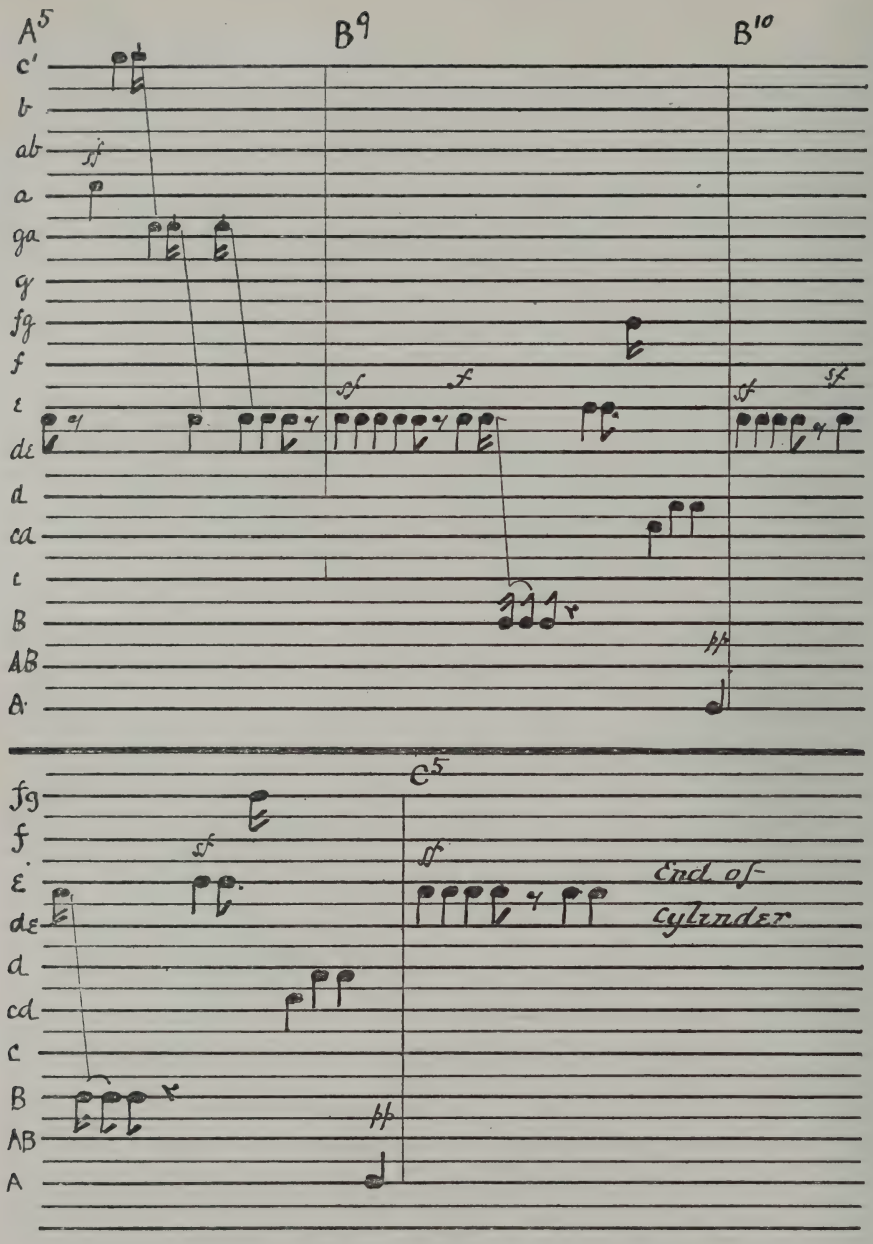
Scheme of record ABBC five times repeated.



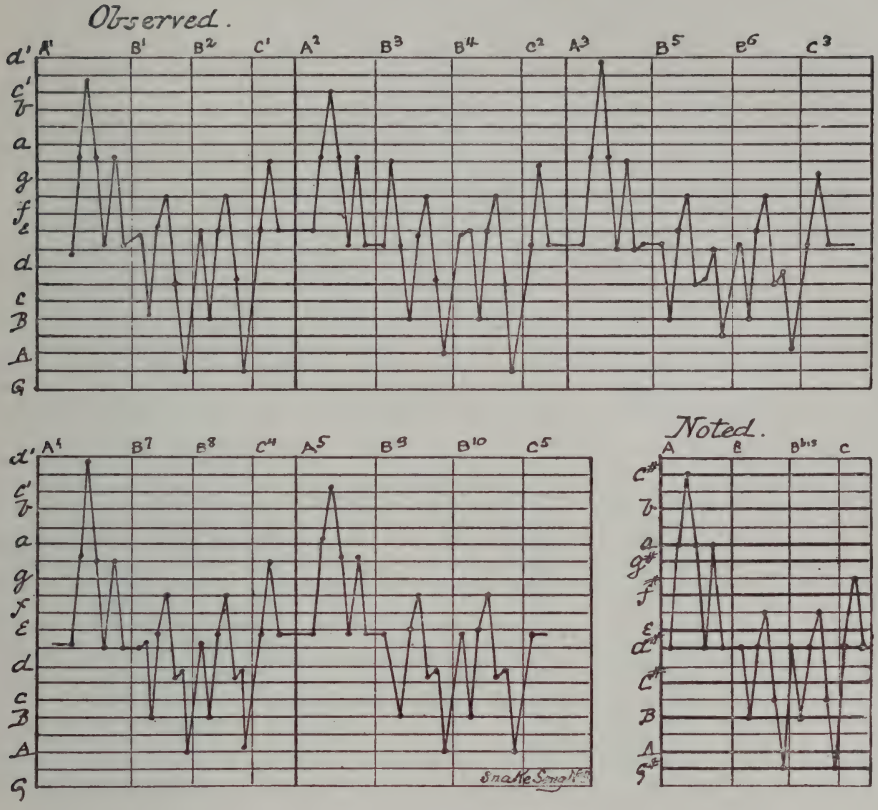

C¹
A²
B³
B⁴
m
sf
sf
sf
pp
pp


C2
A3
B5
B6
C3
d'
cd'
c'
b
ab
a
ga
g
fg
f
ε
dε
d
cd
c
B
AB
A


A4
B7
B8
f
pp
C4
ff


A5
B9
B10
C5
End of cylinder

COURSE OF TONE: SNAKE SONG NO. 3.



ARGUMENT. An augmented triad expands (to d′–de) and contracts (to c′–e) upon a constant axis, ga, without changing the pitch of fourths pendent and balanced from the higher level of its base, the latter supporting another pendent fourth at first attached simply later by laps.

IN this song A consists of a salient augmented triad, which is followed in B by a sequence of a balanced fourth between two pendent fourths, C closing the strophe with a salient major third (fourth in C^2). This general description applies also to the staff notation which registered minuter features of intonation only as indefinite irregularities.

In the phonographic notation the chief of these proves a new type of the displacement of an important note; in this instance the note from which all the segments start and to which A and C return; the

note on which the fourth is balanced remaining meanwhile constant. The change in this axial note is neither a partition, as in No. 1, nor a progressive shift, as in No. 2, but an alternation between two levels, the higher judged either e − or e in nineteen repetitions (in B^1 e+), the lower either de+ or de in eighteen repetitions (in A^1 de−). The alternation is not irregular, but suggests a rhythm of high and low phases with two strophes in each.

In the first strophe the axis is, in general, constant at the high level, the initial segment being a noteworthy exception. For, in passing from this to the next, the singer apparently changes his mind as to his location in the rhythm, suddenly substituting the high axial phase for the low phase he had first chosen. The record of another song of the series (Shiashtasha ; possibly also the next song and others) preserves like evidence of the singer finding himself, or getting his bearings, in a complex rhythm of strophes. In the second strophe the axis wavers between the levels (A and B alternately high and low; C low). It is constant at the low level throughout the third strophe and up to the closing segment of the fourth, when it suddenly regains the initial high level, holding it thenceforward.

Meanwhile the intermediate note of the salient triad of A is closely constant (ga or ga+) in fourteen out of fifteen repetitions (a+ in A^5 without putting the singer astray), and the triad is executed in not far from equal intervals above and below it, becoming during the high phase a minor sixth and during the low phase a minor and even a major seventh (the upper note identically d′ − in both low level strophes).

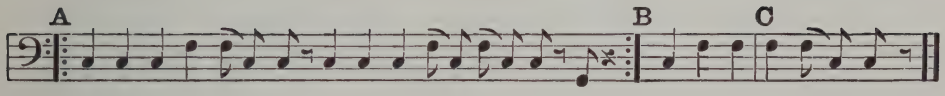
The remaining segments, B and C, of the song exhibit equal definiteness of structure. C closely attains the intermediate note of the triad in three out of four repetitions. Apart from the note A of B^3, the first four B's reproduce one another with great exactness ; and but for the alternation of the axial note the last five reproduce their minutely complex form still more closely. B^5, the exception, duplicates the balanced fourth of the others by a liberty not without charm, and this motive is recalled by the subsequent lapping of the pendent fourth.

The unaided European ear does not appear to advantage as audi-

ence for these Pueblo refinements. Its fallibility as an instrument for the observation of exotic music, due to fatigue and haste, is illustrated in the B of the staff notation. Confusing the two forms of movement with which this segment begins, each repeated five times in the course of the song, it takes the initial interval (de–B) from one and attaches to it the balanced fourth, as this interval is attached in the alternative form. None of the duplications of the balanced fourth are noted, and the first, in B^5, loses its natural motive in the initial de of the segment.

The union in this song of close repetition with delicate alternations of movement well illustrates the difference between freedom and either constraint or license. The singer delivers the melody with the lithe security with which he handles the rattlesnake in whose honor it is chanted. Armor for defense and a scale for guidance would alike be gratuitous hindrances.

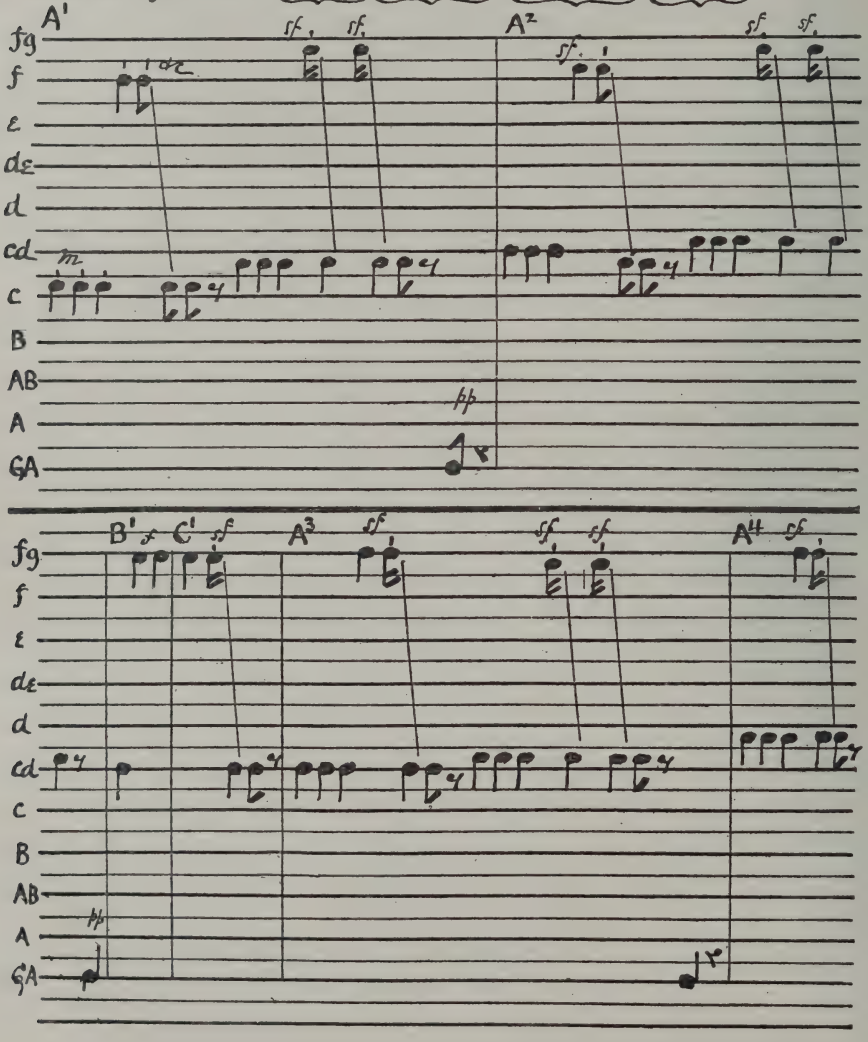
SNAKE SONG NO. 4

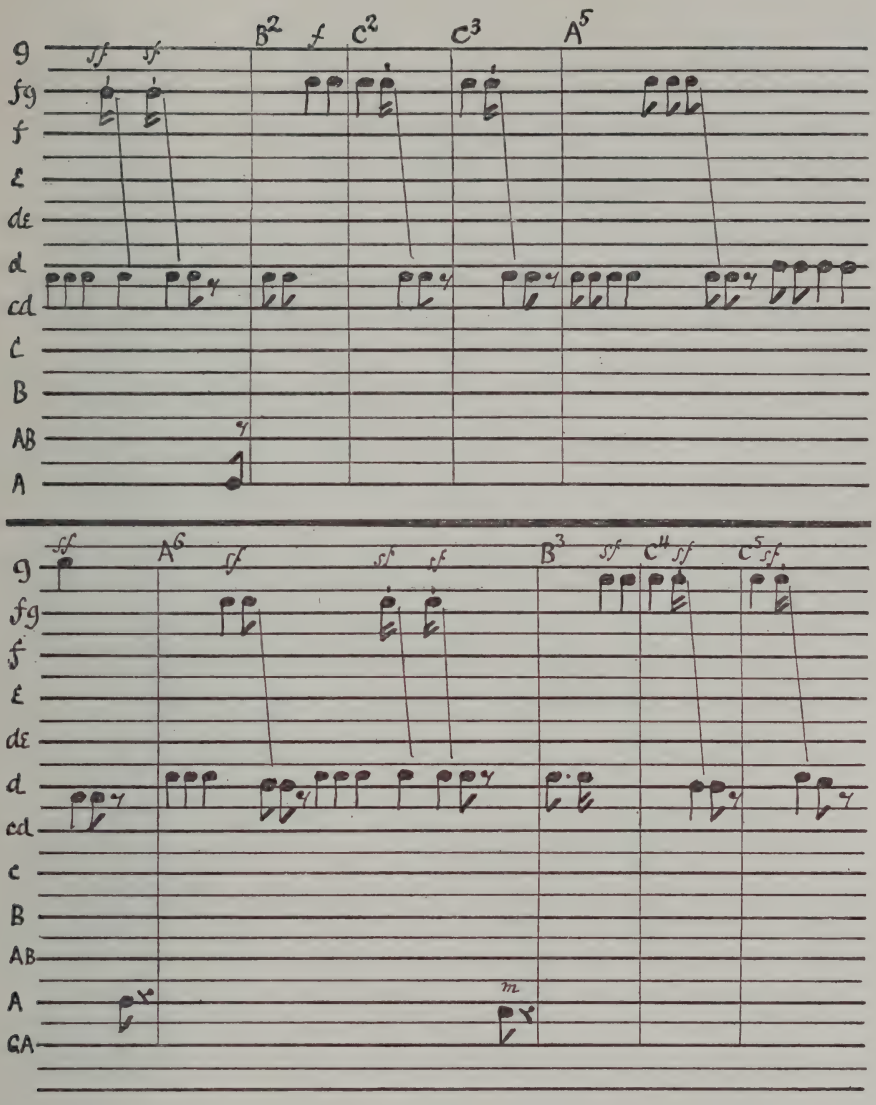


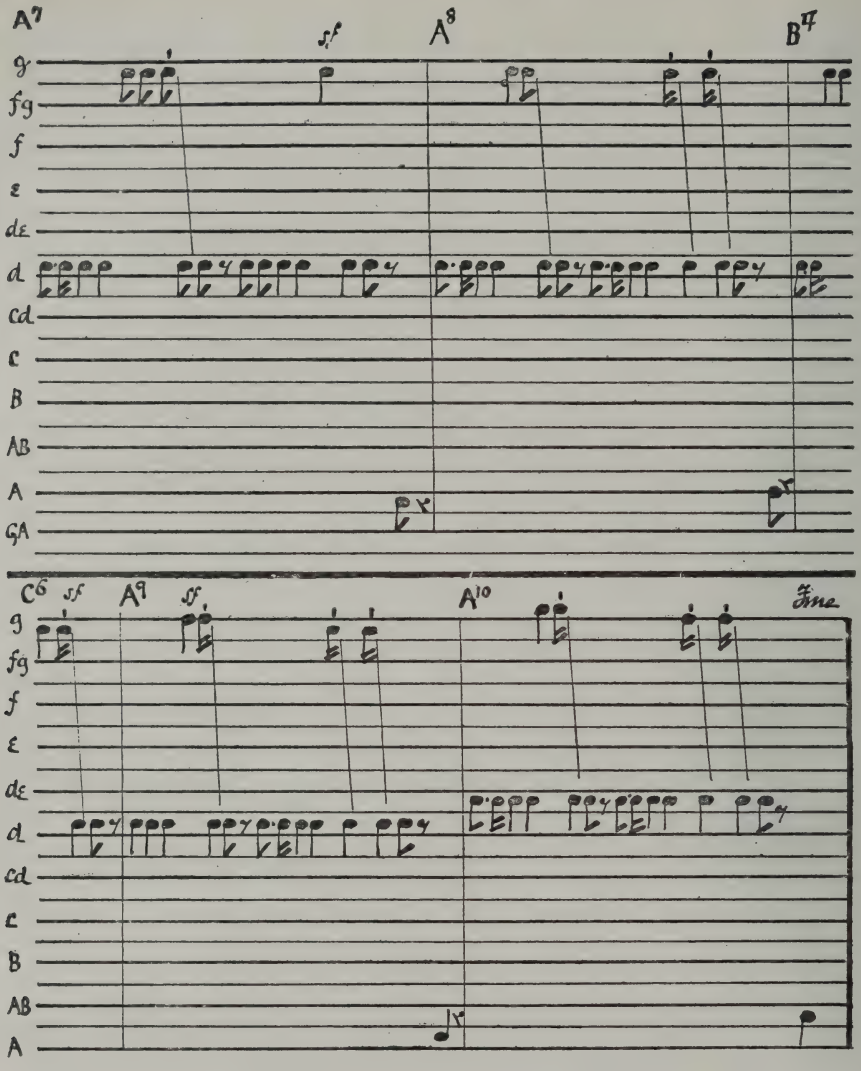
(IV) SNAKE SONG No 4. CYLINDER VI at 168 revs.

♩=110 Accent on successive ♩.

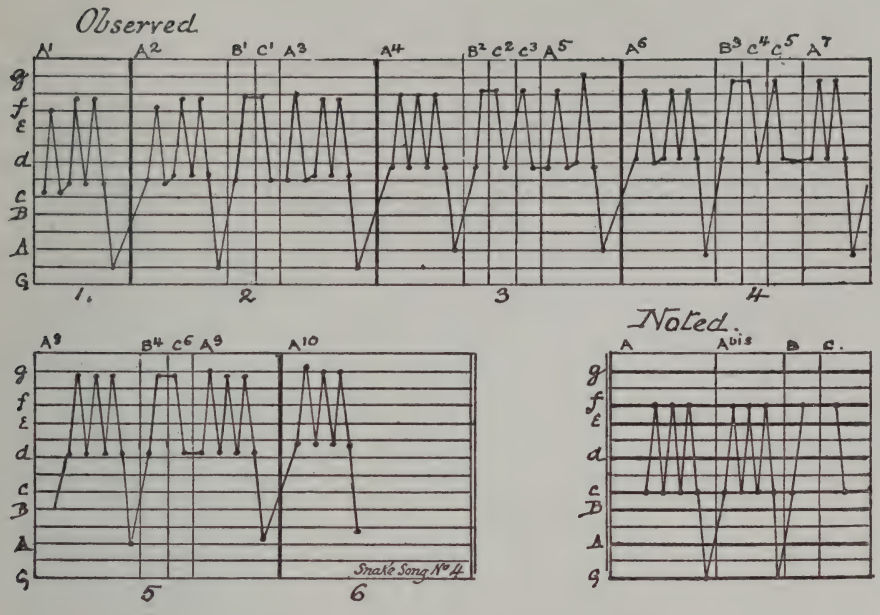
Scheme of record. A'A²B'C' A³A⁴B²C²C³ A⁵A⁶B³C⁴C⁵ A⁷A⁸B⁴C⁶ A⁹A¹⁰




g
fg
f
E
dE
d
cd
C
B
AB
A
B2
f
C2
C3
A5
sf
sf
A6
sf
sf
sf
B3
sf
C#
sf
C5
sf
c
GA
m


A7
sf
A8
B4
g
fg
f
e
de
d
cd
c
B
AB
A
GA
C6
sf
A9
sf
A10
Fine

COURSE OF TONE: SNAKE SONG NO. 4



ARGUMENT. The axis of a major augmented triad, fg–cd–GA, rises by successive third tones, the extremes alternately resisting and yielding to the advances.

THIS is the simplest song of the series, consisting of repetitions of a salient major third, generally redundant, from a reiterated note, every other duplicated and punctuated by a pendent fourth, generally redundant also, and every fourth one followed by another in which the upper instead of the lower note is reiterated. Divided notes (B^2 to B^4, A^5, A^7–A^{10}), the omission of the duplicate third in A^5 and A^7, and the introduction of a duplicate in C^3 and C^5 vary this rudimentary scheme.

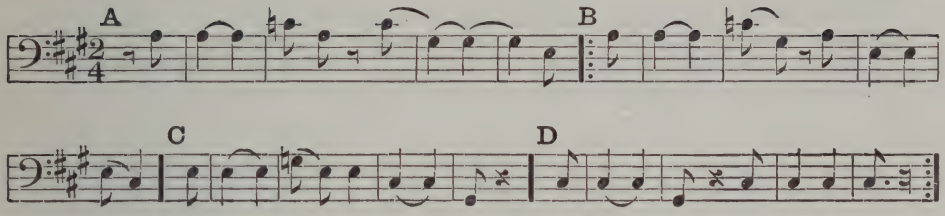
The chief formal features of the song are again a displacement of its axis and an attendant shaping of its figure. Conceiving the performance as consisting of four complete strophes introduced by the final segment of a fifth and closed by the initial segment of a sixth, the singer raises the axial note an approximate third tone in passing from each strophe to the next, with one exception (4 to 5) where it remains constant.

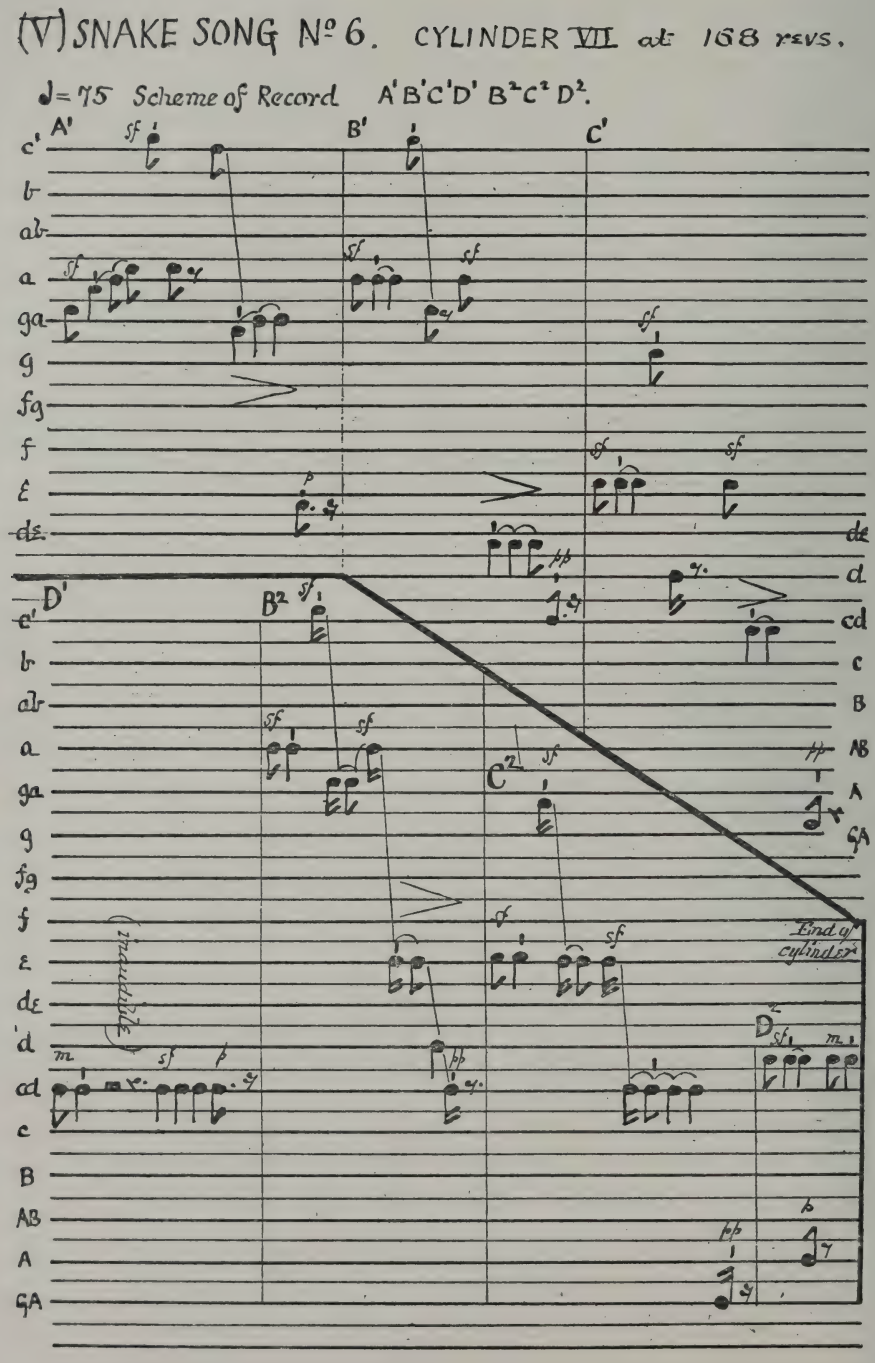
Within all but the opening fragmentary strophe the axis is either exactly constant (5 and 6) or mainly so (in 2, once $\frac{1}{3}$ tone, five times $\frac{1}{6}$ tone flat; in 3, once $\frac{1}{6}$ tone sharp; in 4, once $\frac{1}{12}$ and twice $\frac{1}{6}$ tone flat). A marked exception occurs as before only in the initial segment of the song, and again admits of interpretation by a change in the singer's conception of his place in the strophe, which he seems to imagine at first completed and later continued.

The shaping of the figure executed results from the initial resistance opposed by the two outlying notes above and below, to the upward movement of the axis, about which the augmented triad they form sways as in Song 2. Under the first upward shift from 1 to 2 both boundaries hold, the upper interval being compressed toward a major third and the lower stretched beyond a fourth: from 2 to 3 both yield, the lower at once by a semitone, the upper finally giving way a semitone after yielding by successive sixth tones: from 3 to 4 both hold again, the upper interval contracting, the lower expanding; the former exactly righting itself at the end of the strophe, the latter approximately at the end of the next: finally from 5 to 6 both boundaries move with the axis, the upper reacting $\frac{1}{6}$ tone, but leaving the upper interval redundant as at first.

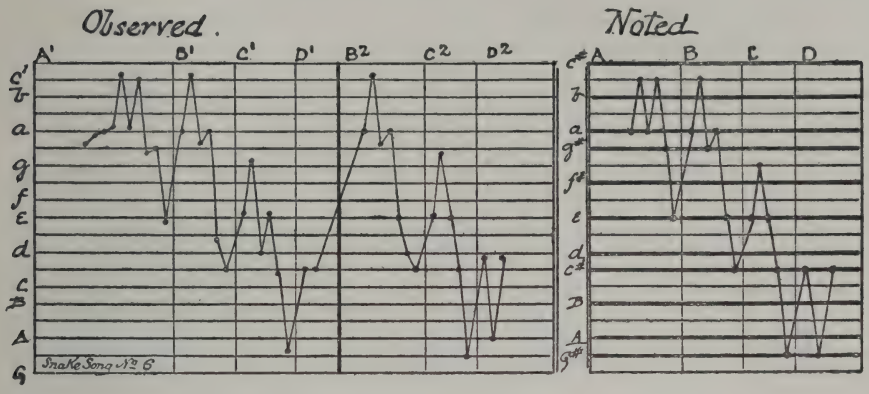
The interest of the song lies in its stately rhythm, occasionally delicately varied; and in this deliberate ascent, as if from level to level of the singer's native mesa, with a pause midway in each to rally loiterers. Forced by the diatonic prison-grating that checkers to the European sense every landscape of tone, to interpret this steady displacement as a negligible inaccuracy, the unaided ear reduced to a dead level of monotony a performance whose uneven plenitude of interval and stealthy upward tread possess no little dramatic fascination.

SNAKE SONG NO. 6




(V) SNAKE SONG Nº 6. CYLINDER VII at 168 revs.
♩= 75 Scheme of Record A'B'C'D' B²C² D².
A'
B'
C'
D'
B²
C²
D²
End of cylinder
Translation

COURSE OF TONE: SNAKE SONG No. 6



ARGUMENT. An augmented tetrad built up, A, from a minor third, c′–a, and an augmented triad, c′–ga–e, pendent from its summit, is developed, B, by attaching the triad to its upper mediant, a, by a lap with the lower, a–(e)de–cd, and then transferred, C, to its original base, e–cd–GA.

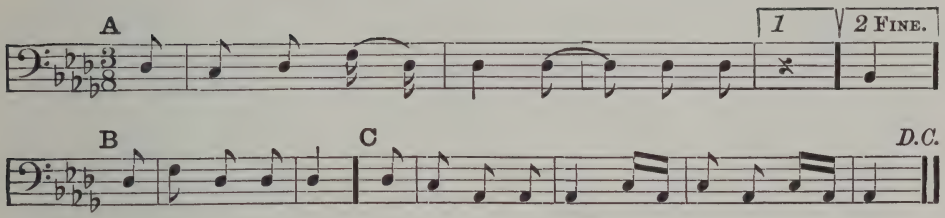
IN this song a salient minor third followed by a downward triad spanning a minor sixth from its summit (A) is twice repeated; first (B) with the triad shifted down a minor third and attached to the third by a lap, then (C) with the whole movement as thus modified shifted down a fourth (the lap omitted in C^2). The triads are variously divided, in B^1 at de, in B^2 at e with an added note, d, at the fifth, to which D^2 returns in closing, and with which the principal notes of the texture outline two fifths lapping by a tritonus (a, ga–d, cd). Apart from these variations, the repetitions are in general very close; identical between B^1 and B^2, and varying widely only in the first movement of C and in D.

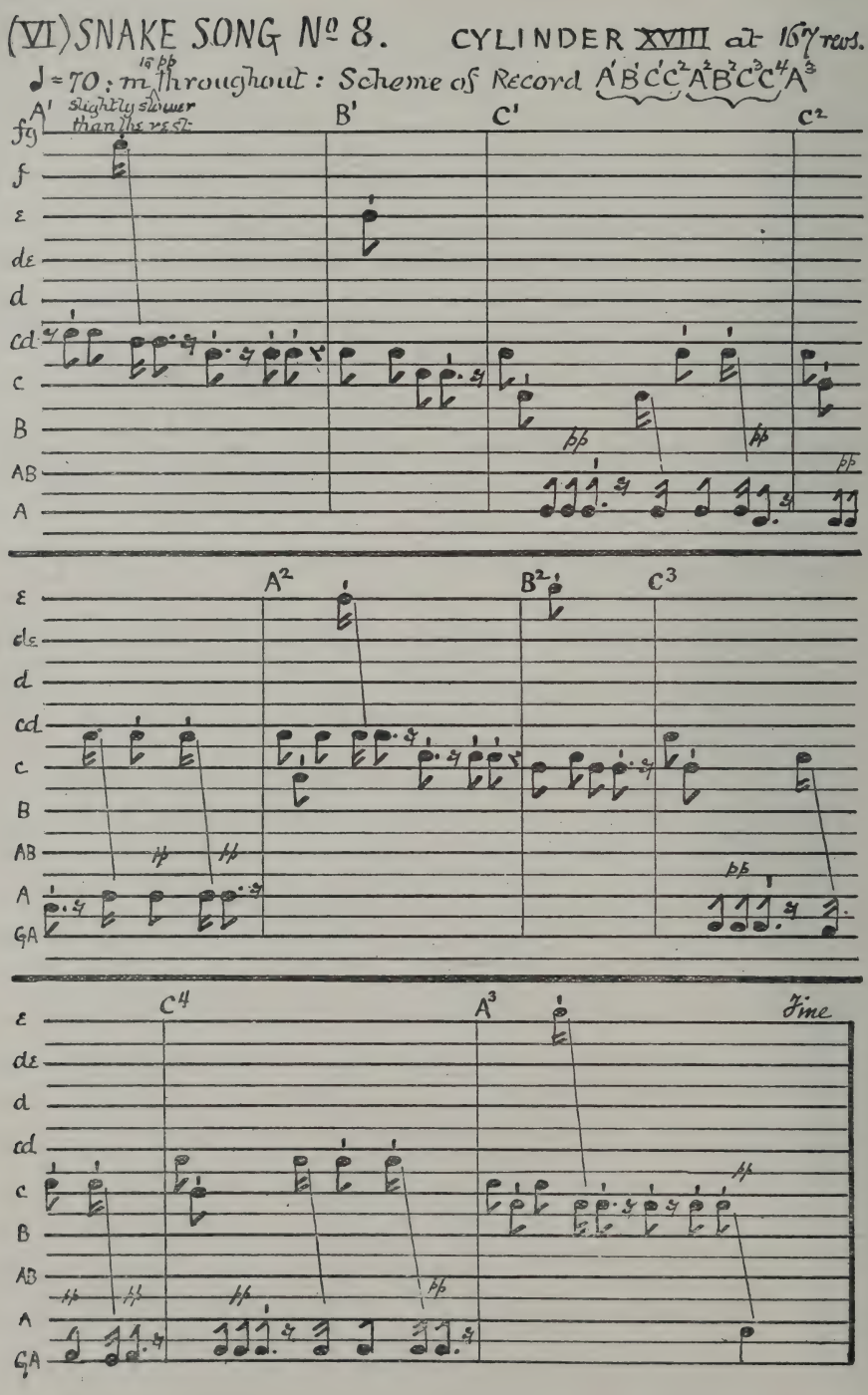
The interest of this song does not lie in flexibility of structure, of which it has none, unless a shift be in preparation in D^2, but in the apparent dependence of its form upon after images of previous notes. The initial segment, A, epitomizes the composition. The downward triad attached to its topmost note, c′, is in B attached to the next lower, a, with a lap reproducing the next lower (initial and dividing), ga; and the whole movement is in C suspended from the final and

lowest of all, e. Each division of the triad in B^2 repeats (in B^1, perhaps, aims at) a previous note. The first fall in C^1 is not to a previous note, but through a familiar interval; yet C^2 appears to aim at the previous ga, and in both the triad is divided on the previous cd. Conservatism of fancy rules in place of the roving enterprise of previous performances.

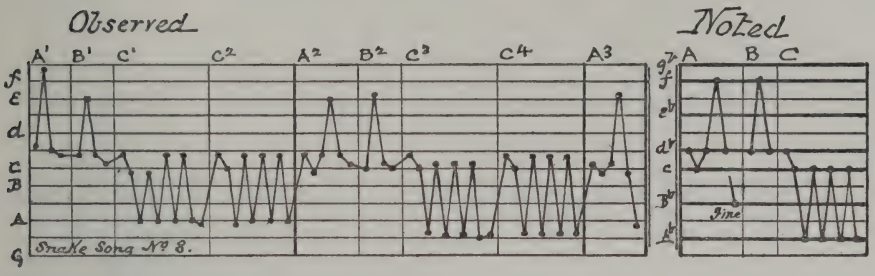
A minor sixth can be attached to a minor third, as in the B's and C's of this song, only in the minor diatonic mode with both major and minor seventh; and cannot there be divided as in B. The ear recognized the adiatonic character of the song, and the staff notation is a correct rendering of its general movement.

SNAKE SONG NO. 8




(VI) SNAKE SONG No 8. CYLINDER XVIII at 167 revs.
♩ = 70 : m throughout : Scheme of Record A¹B¹C¹C²A²B²C³C⁴A³
A¹
Slightly slower than the rest
B¹
C¹
C²
A²
B²
C³
C⁴
A³
Fine

COURSE OF TONE: SNAKE SONG NO. 8



ARGUMENT. A downward tetrad (e–cd–c–A) of which the lower interval is expanded by lapping (to cd–A) is then augumented through the subsidence of the base (to GA), the lower interval again expanding (to a fourth) by lapping; and is later restored by the rise of the base (to A).

THIS song is as relaxed and dreamy as the last but one (No. 4) is tense and expectant. The contrast involves vigor of delivery, here m. to pp., there f. and sf.; the distribution of the movement, here mainly confined to the lower part of the tract covered, there to the upper; and the amplitude of the intervals, here chiefly minor and major thirds, often deficient, there chiefly major thirds and fourths, often redundant.

The opening approximate fourth (A^1) is the single bold movement of the song, and the downward shift characteristic of the subsequent melody announces itself as a $\frac{1}{6}$ tone in the descent from it. Thereupon the movement forms a tetrad out of a minor third and deficient semitone (B^1) followed by a reiterated third, first simply attached (C^1 excepting the last two returns), then lapped across the semitone (C^2). A second strophe expands the tetrad a semitone downward, reducing the movement of A from a fourth to a minor third between semitones, extending B downward and lapping C^4 over C^3 as C^2 had lapped the first part of C^1. A third strophe just begun restores the tetrad to its original span by making A the final note of the song.

There is a slight unsettlement of pitch in recommencing the reiteration of the third in each strophe, the base, A(GA), of the tetrad being otherwise almost perfectly constant. Apart from the initial substitution of a fourth for the subsequent minor third, the upper limit is constant

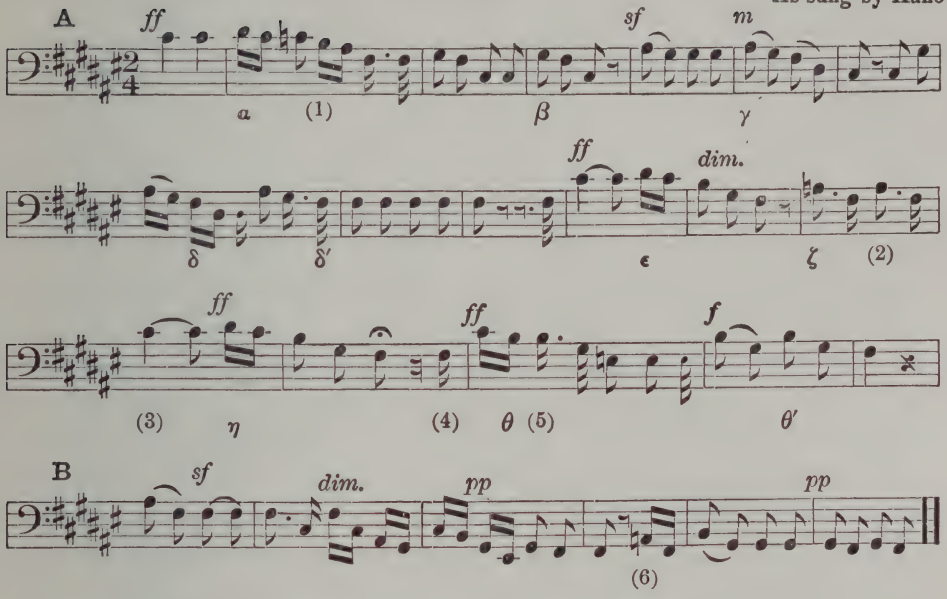
within a sixth tone. The lower limit of the intermediate semitone varies $\frac{1}{3}$ tone, but the upper limit remains absolutely constant through the two complete strophes. Its third tone fall in commencing the third strophe appears the faltering announcement of the end of the song, which forthwith sinks prematurely through the initial minor third with the suddenness of a falling breeze.

The vivid expression, in this song, of depressed emotion, — lassitude or melancholy, — notable in its small downward shifts and expansions, and in the narrow timidity of its intervals, only ephemerally redeemed in C^3 and C^4, passed unrecognized by the unaided ear, to which it lay in the major diatonic key of $D^\flat$. Actually, assuming that the singer meant a semitone by his intermediate transitions averaging less than that interval, it lies within $D^\flat$ minor with major seventh. The distinction of a tone in span between the opening salient interval and all the others, particularly expressive through its slower delivery, also passed unnoticed; and the final note was heard a semitone from where it was. Thus unwittingly mutilated, the melody lost both its gleam of light and its pervading shadow.

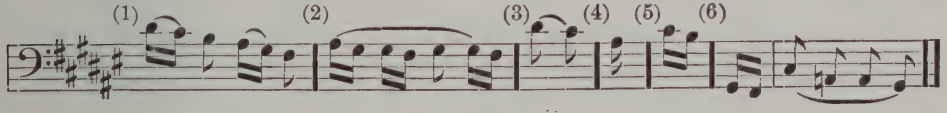
MALO-KATCINA

BY KANO AND BY MASI-UMTIWA

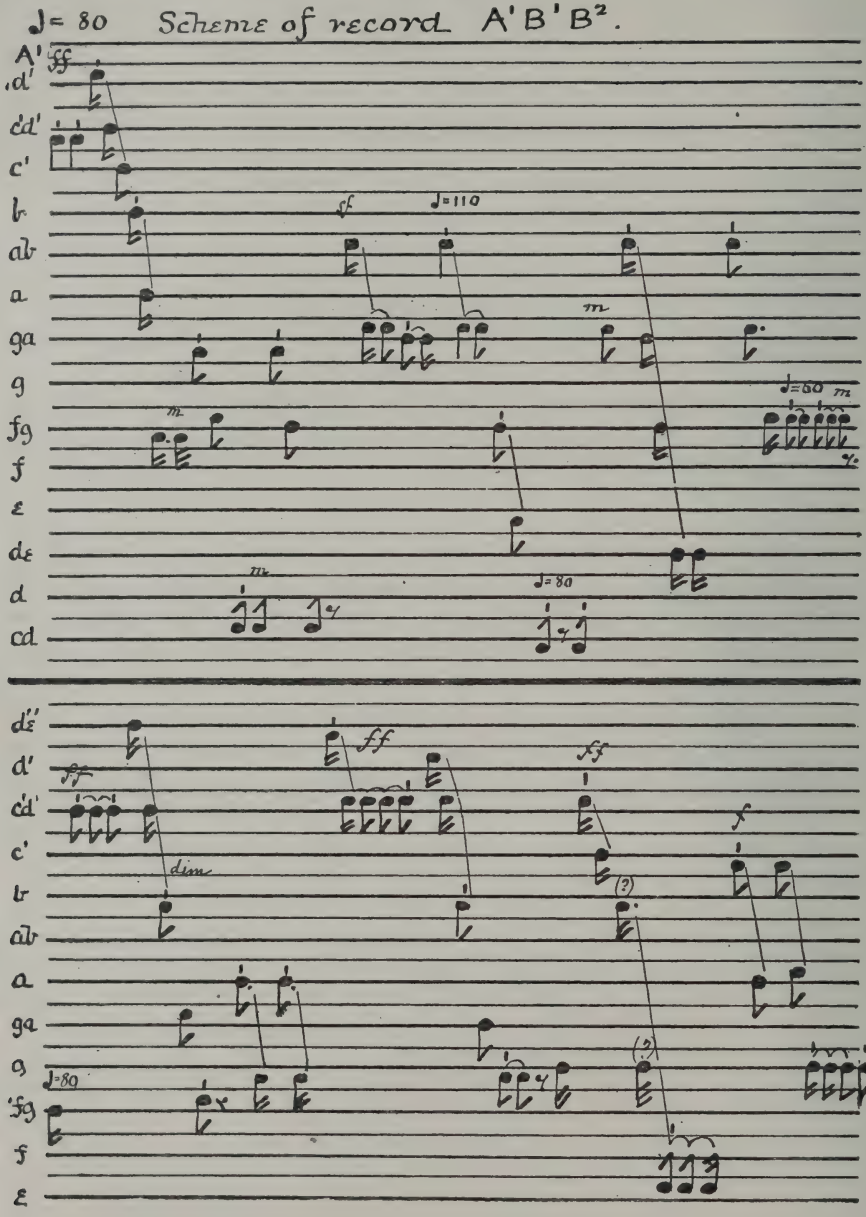
As sung by Kano

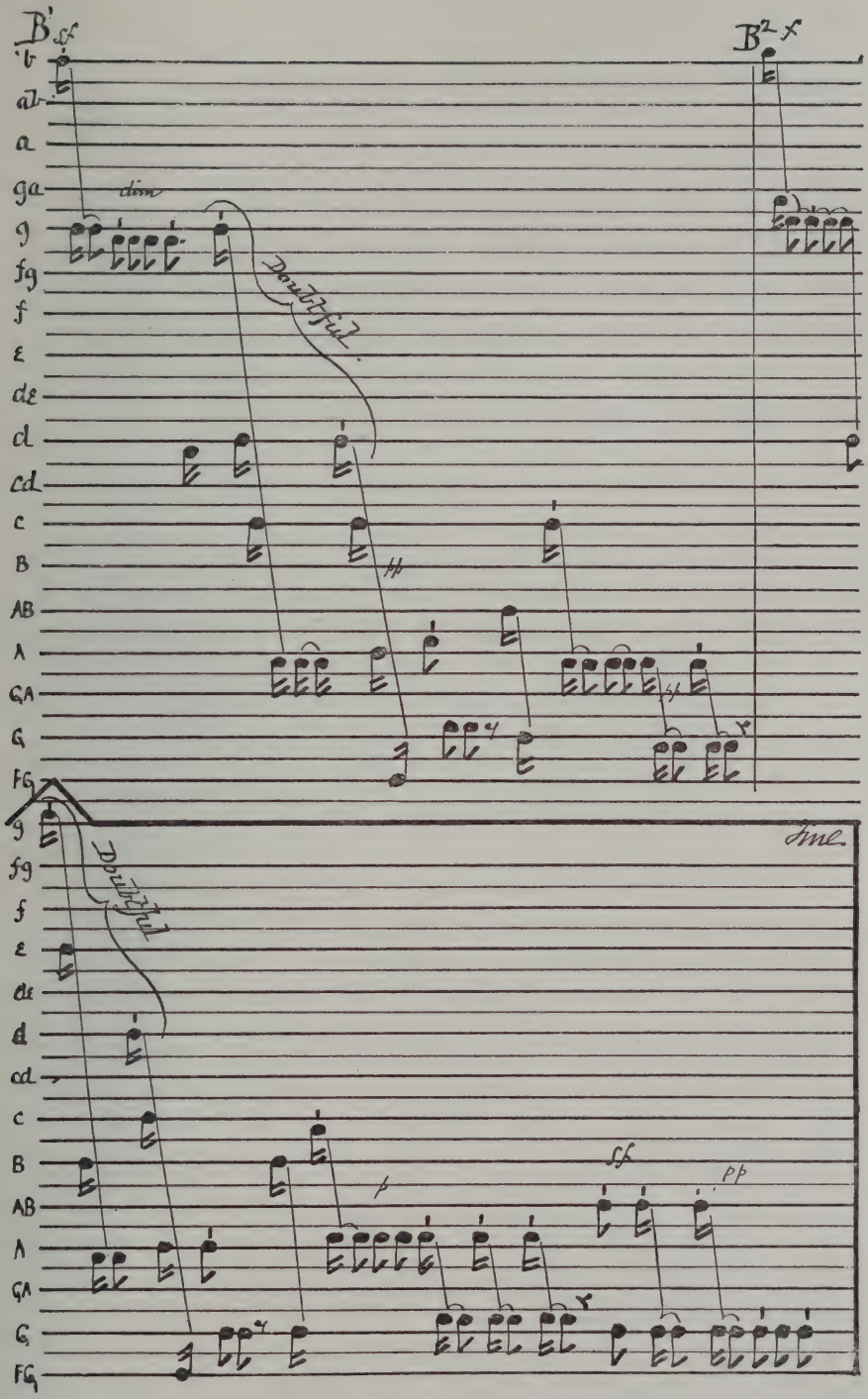


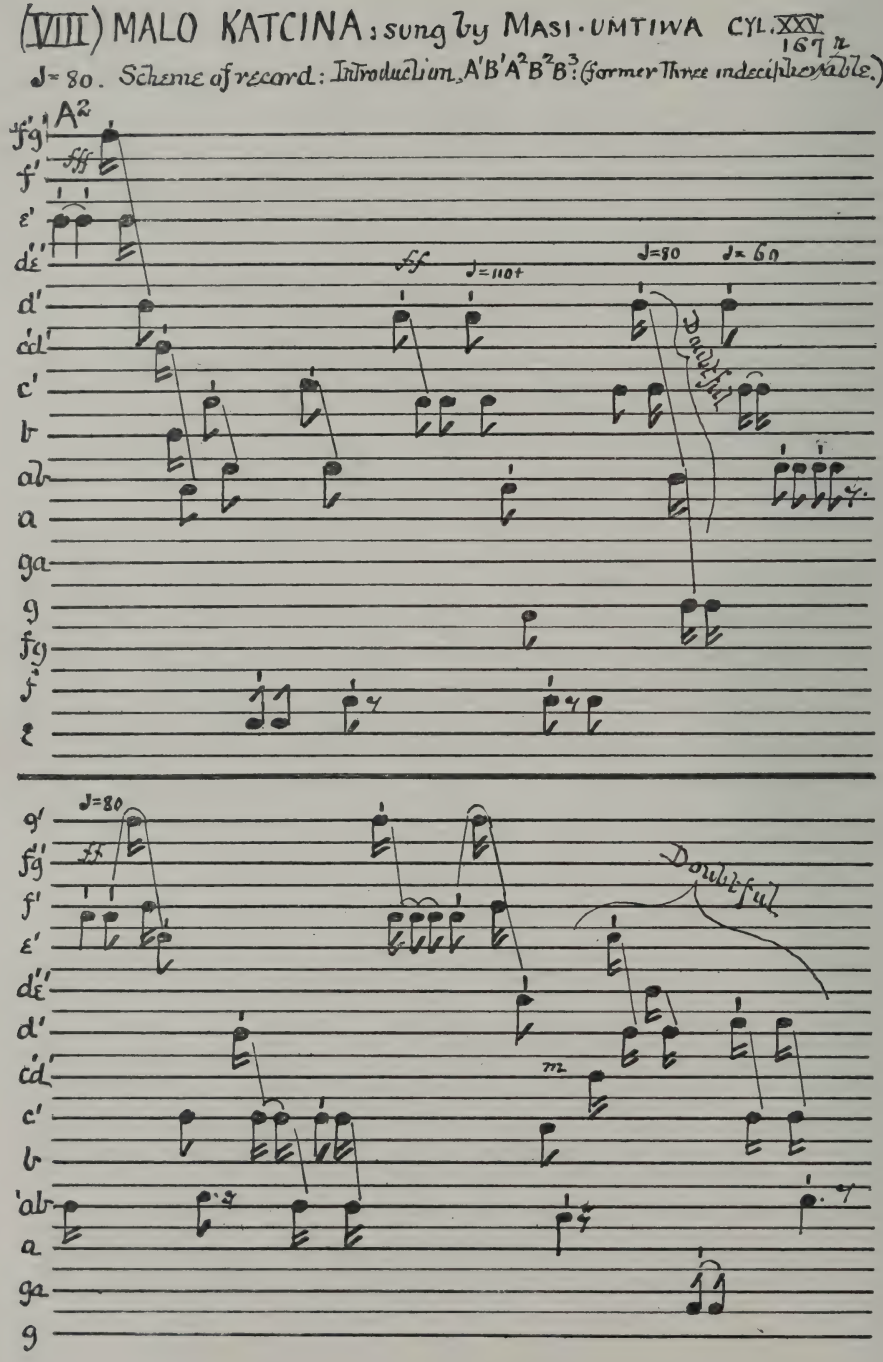
At the points numbered Masi-umtiwa's song varied as follows: —

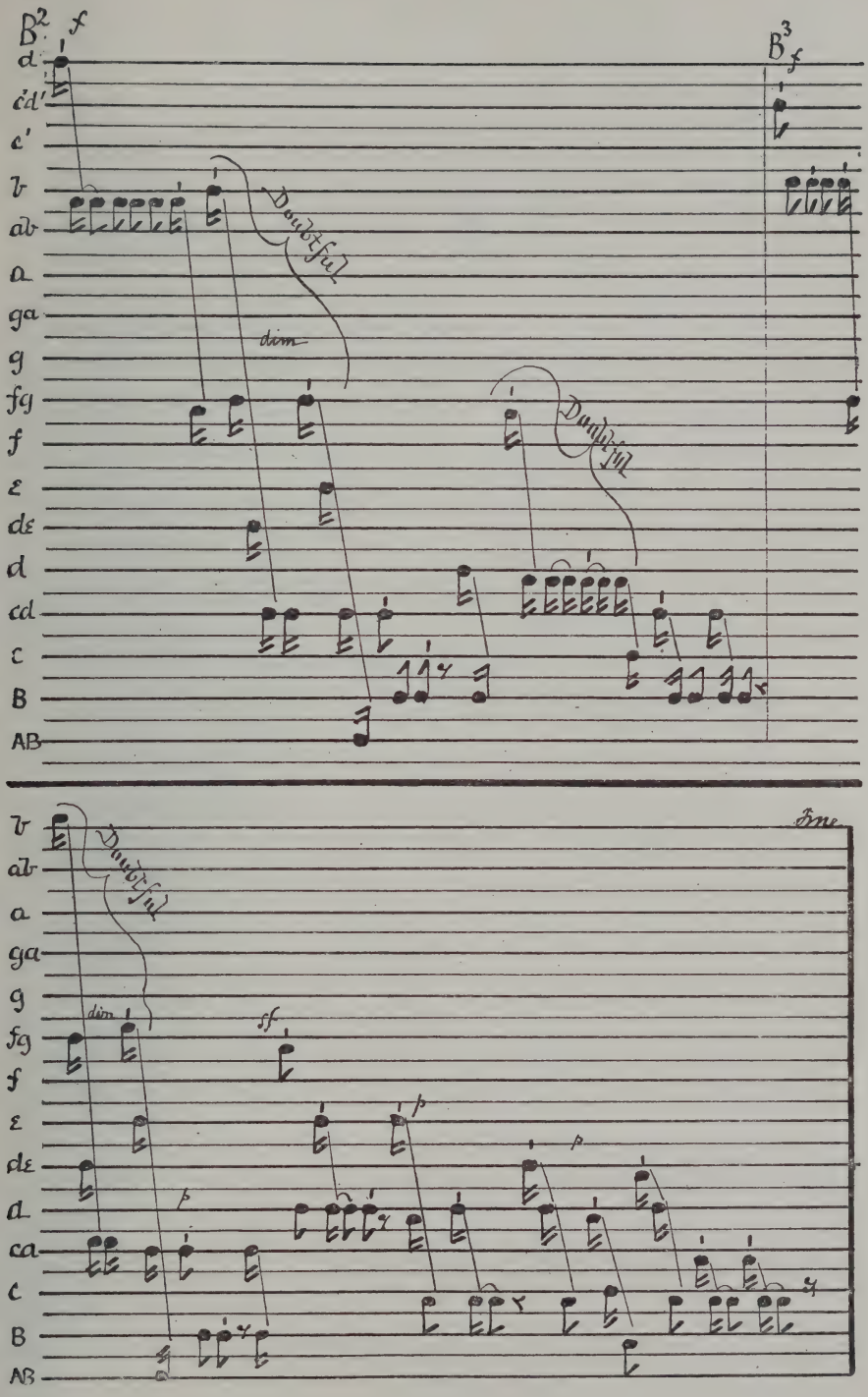


(VII) MALO KATCINA: sung by KANO. CYL IV at 167r.

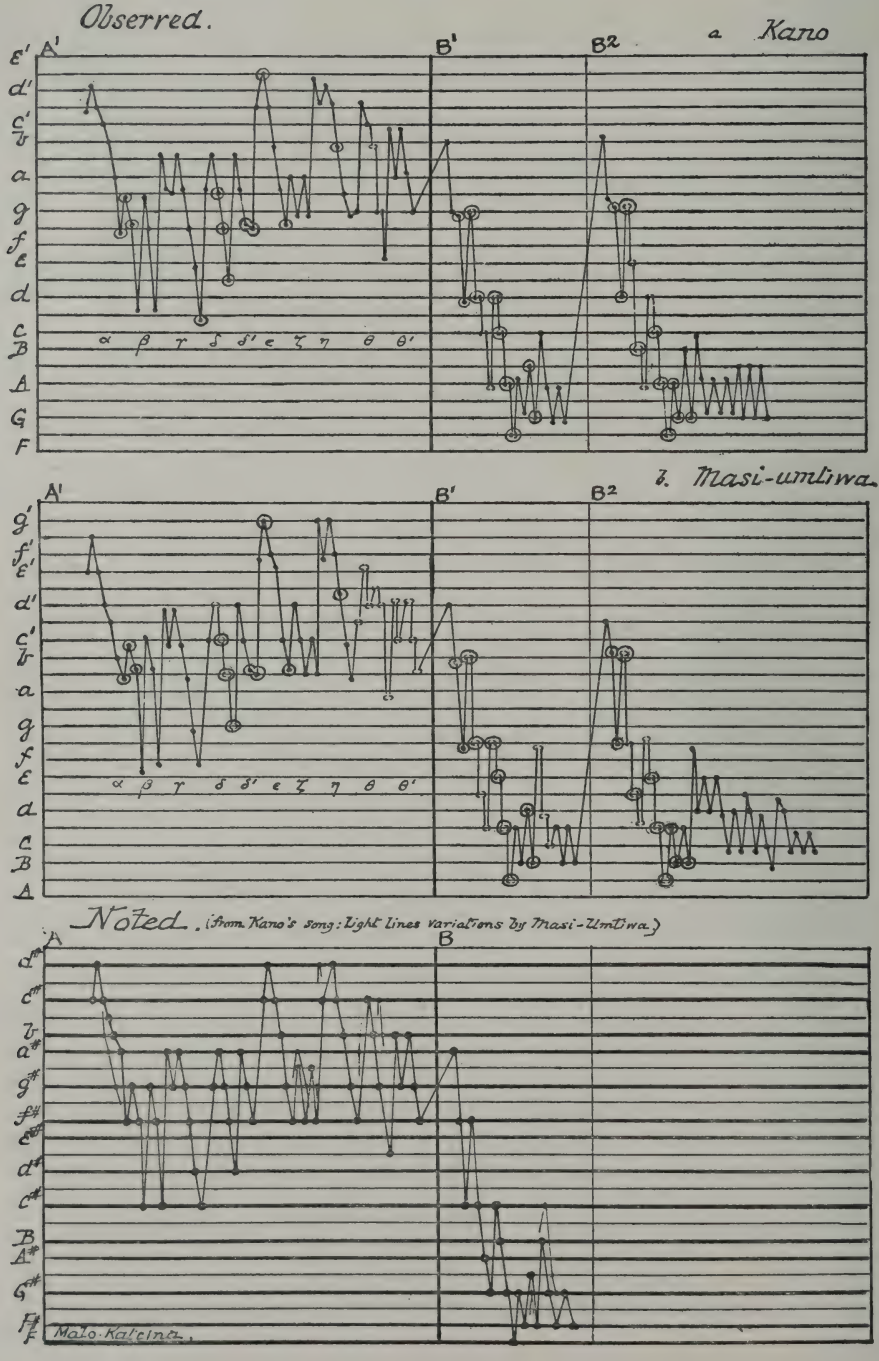



B' sf
B² f
dim
Doubtful
Doubtful
fine
sf
pp
b
a♭
a
ga
g
fg
f
ε
dε
d
cd
c
B
AB
A
GA
G
FG


(VIII) MALO KATCINA: sung by MASI-UMTIWA CYL. XXV 167 a
♩= 80. Scheme of record: Introduction, A¹B¹A²B²B³ (former three indecipherable.)
A²
fff
sf
♩=110+
♩=80
♩= 60
Doubtful
Doubtful
♩=80
ff
m


B2
f
B3
f
Doubtful
dim
Doubtful
Doubtful
dim
ff
p
p
p
Fine

COURSE OF TONE: MALO-KATCINA



ARGUMENT. A tetrad in a major reading (in Kano's song c′d′–b–a–fg ; in semitones 2.2.3.) is shifted a fourth downward (to ga–fg–e–cd), completing the octave of its summit ; and returning exchanges (in ζ) its own lower interval (fg–a) for that (a–g) of a minor reading (in semitones 2.3.2.) and escapes from the resulting tritonus (in semitones 2.2.2) by an octave downward shift from the new base (g). The latter process takes place also by attraction (?) in a rendition which presents the minor reading from the start.

THE outdoor music of the collection begins with this gay, almost rollicking melody, shaded by both singers from a stentorian opening to a whispered close. The preceding songs have warranted the anticipation of both exact repetition and free variation in renditions of the same air by different performers ; but if the divergence between Kano and Masi-umtiwa is therefore not surprising, the precision with which they weave the pattern both follow nevertheless is. In the diagram of Kano's song the notes in circles embody the identical order of intervals that their homologues similarly indicated compose in Masi-umtiwa's song, performed a major third higher. Taking off a tracing from one diagram and applying it to the other so that the goals of the first downward movement (ending at fg − in Kano's song) coincide as a common start, the diagrams "register," to use the printer's word, at the notes in circles. The rise from the start was made through a tone, the fall thereafter through a $\frac{2}{3}$ tone by both singers : both pitched the reiterated note before the high leap later a third tone, and the passing note from which it was taken a sixth tone above the start; both pitched the climax of the song a sixth tone over a major sixth above the start; both began their second downward leap in B^1 at a semitone, and in B^2 at a $\frac{2}{3}$ tone above the start ; and when at the end of B^2 they parted company, each to execute his own coda, both had reached a pitch a sixth tone less than a major seventh below. Meanwhile the axis of the song had been sprung through an approximate semitone by each in his own way. Such exactness would be hardly credible were it not substantiated by two mechanical records.

The song adds another to the endlessly varying dramas of melodic

discord and resolution of which this music is the theatre. In Snake Song No. 1 a tritonus is escaped by an upward swell of the figure (from g–cd in B^2 and B^5 to ga–cd in C^1 B^3 and C^2 B^6); here by a similar movement not actually executed but mirrored in the lower octave, — like a defeated plan in the unchanged purpose.

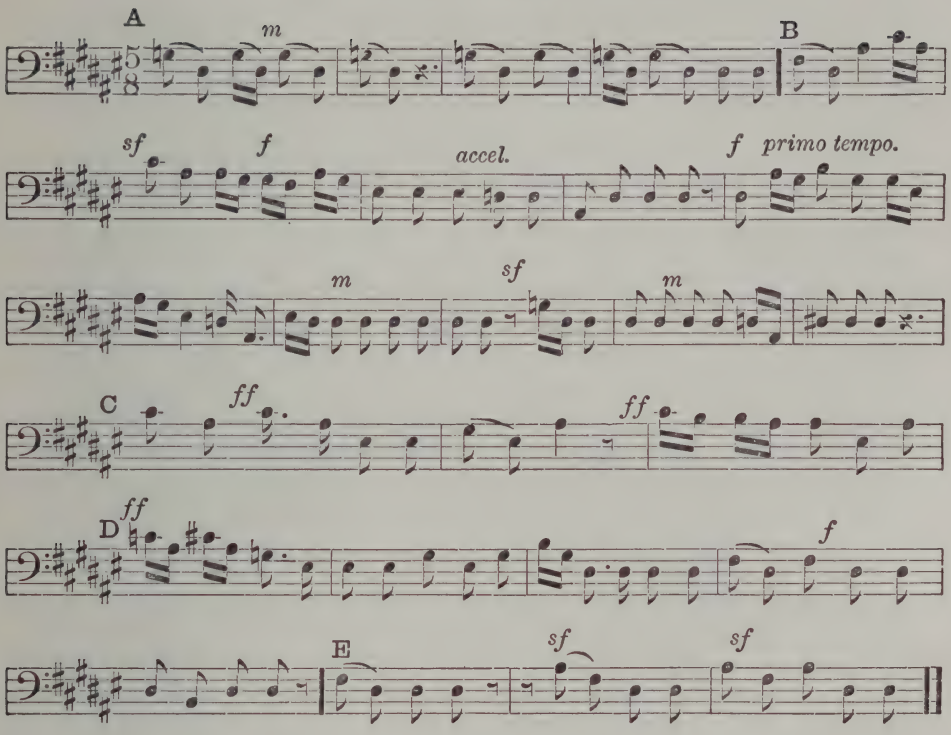
The subject of these vicissitudes is a downward tetrad extended by an opening flourish of a tone; and their source lies in the partial substitution of a minor reading of this movement (ending in a minor trichord, as shown in Masi-umtiwa's γ) for a major reading (ending in a major trichord, as shown in Kano's γ). The course of the song may thus be described: The theme is given at once by way of introduction (α) in a form hardly recognizable, but showing traces in each rendition of the reading characteristic thereof, and cramped a semitone: it is then sketched (β) to the octave (cd) of its summit (c′d′), that is, shifted down a fourth; then fully revealed in the two readings (major in Kano's γ; minor in Masi-umtiwa's), to be quickly withdrawn first within its upper three intervals (δ), then its upper two (δ'), to prepare its reappearance at the original pitch, which after a delayed note and a moment's pause ensues (ϵ). The way is plain before Masi-umtiwa from this point, the c′ demanded by his minor reading of the theme already echoing in his ears from the movements in the δ's. But for Kano in the major reading immediately ensues a struggle, the pitch it demands, here a, yielding at first (ϵ) to the after image of the previous ga, and asserting itself later (ζ) only to assume their relation (a tone) to the note next below. This compromise springs the axis of the song upward a semitone from this point on, and at first the axis alone. Repeated unchanged (η) but for the loss of its lower semitone, the theme comes to span a tritonus (c′d′–g). The same tritonus introduces the quick development of the theme a tone downward (θ), by which the plunge in B is foreshadowed, as in the like quick development shifted a tone upward (δ') the rise of the theme in returning to the initial pitch was before announced. The immediately following rehearsal of the two lower intervals of the tetrad (θ') in its minor reading nearly fills the tritonus field; but on proceeding to B, while still submitting to the new

base, the singer finds ample space in its lower octave to execute a complete tetrad of the normal dimensions.

Force of example solely, and no inner constraint of the music, seems to explain Masi-umtiwa's assumption of the identical new base in his B's. The key to the structure of the song appears in Kano's version, the influence of which upon Masi-umtiwa is possibly also to be seen in his tritonus ascent in θ. In both performances of B by both singers the notes of the octave fall were too rapid to follow with entire security even in the phonograph, as some of the earlier notes had already been. While suspecting that the appearance of a chord of the dominant seventh in this sequence was a figment of the harmonic sense, the ear was powerless to penetrate the disguise.

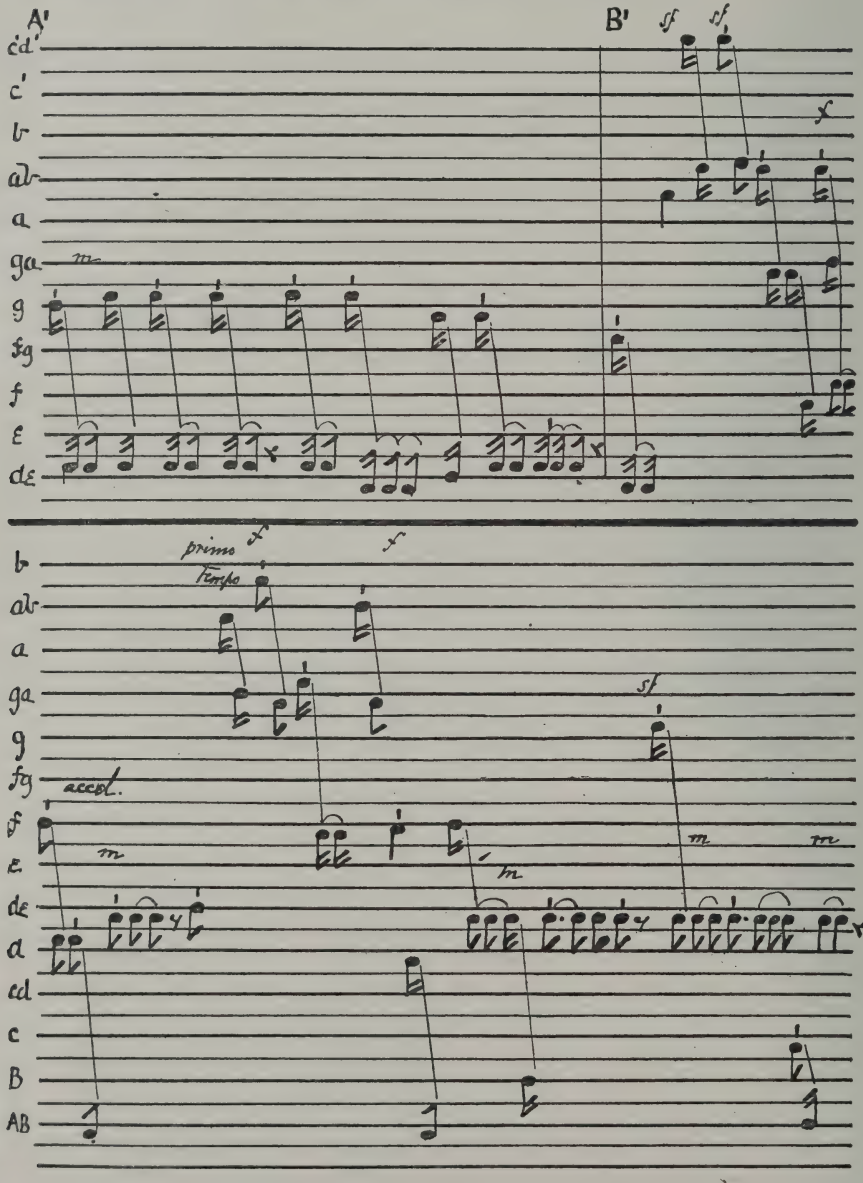
The semitone axial displacement from A to B, its anticipation in Kano's ζ to θ, and hence, if the foregoing auditory explanation of its occurrence be correct, a cardinal element in the musical content of the song, are unrecorded in the staff notation. Apart from a few wholly recalcitrant notes (c′, a, e, A), the ear made very easy work of putting the melody into the diatonic key of F♯ major. In this process α was stretched a semitone beyond the span given it by both singers, and Kano's adiatonic major reading of the tetrad was set aside for Masi-umtiwa's minor reading, which falls within diatonic limits; while numerous isolated notes outside the scale were neglected *en masse* as waifs. This staff notation well illustrates the process of unconscious selection by which the ear tends to retain from a rapid performance only such features as approximately embody diatonic form, rejecting others, except in glaring cases, as negligible aberrations. Through this innocent *petitio principii* the case for the diatonic scale is won in advance.

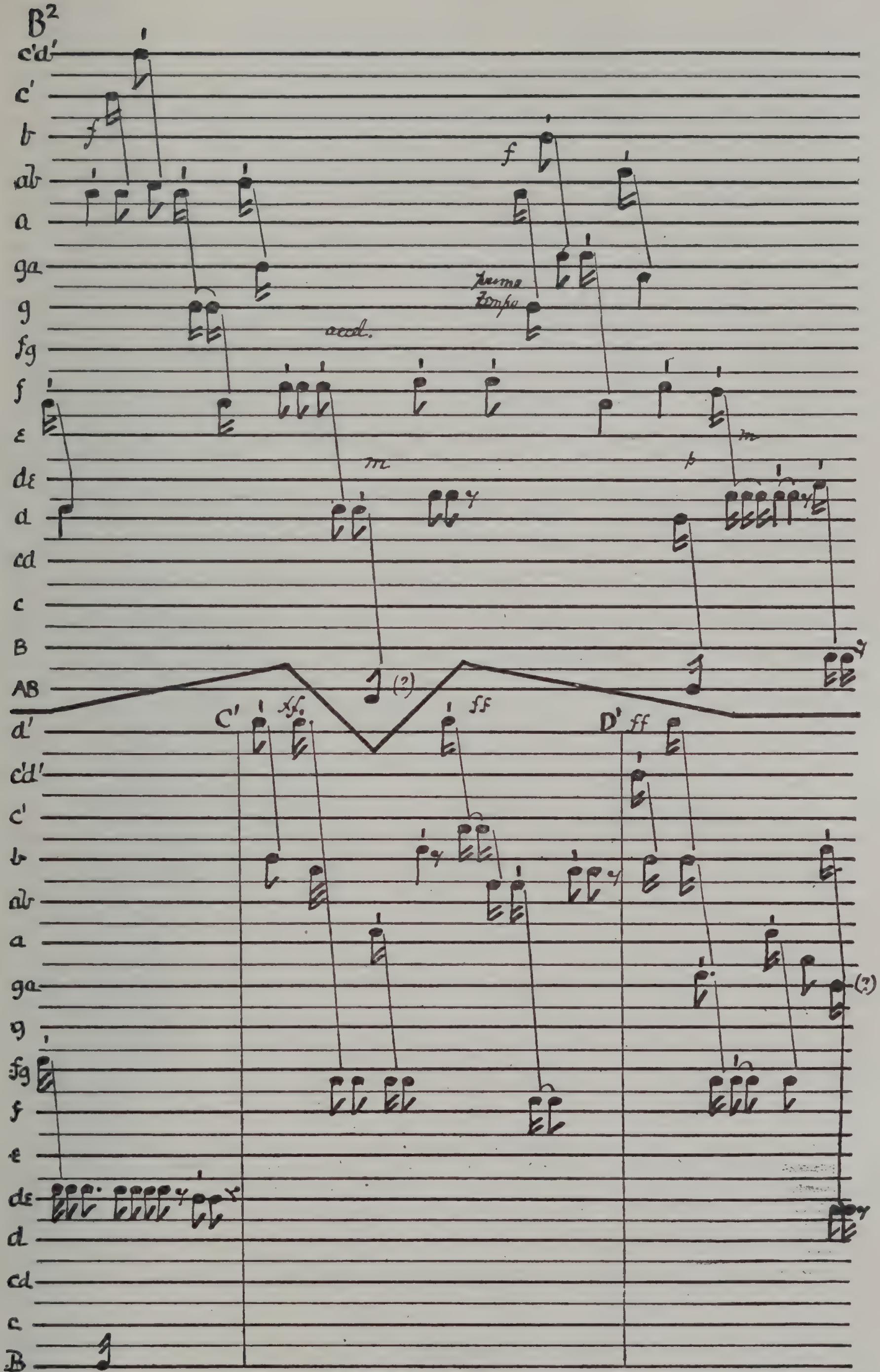
ÇOYÓHIM-KATCINA

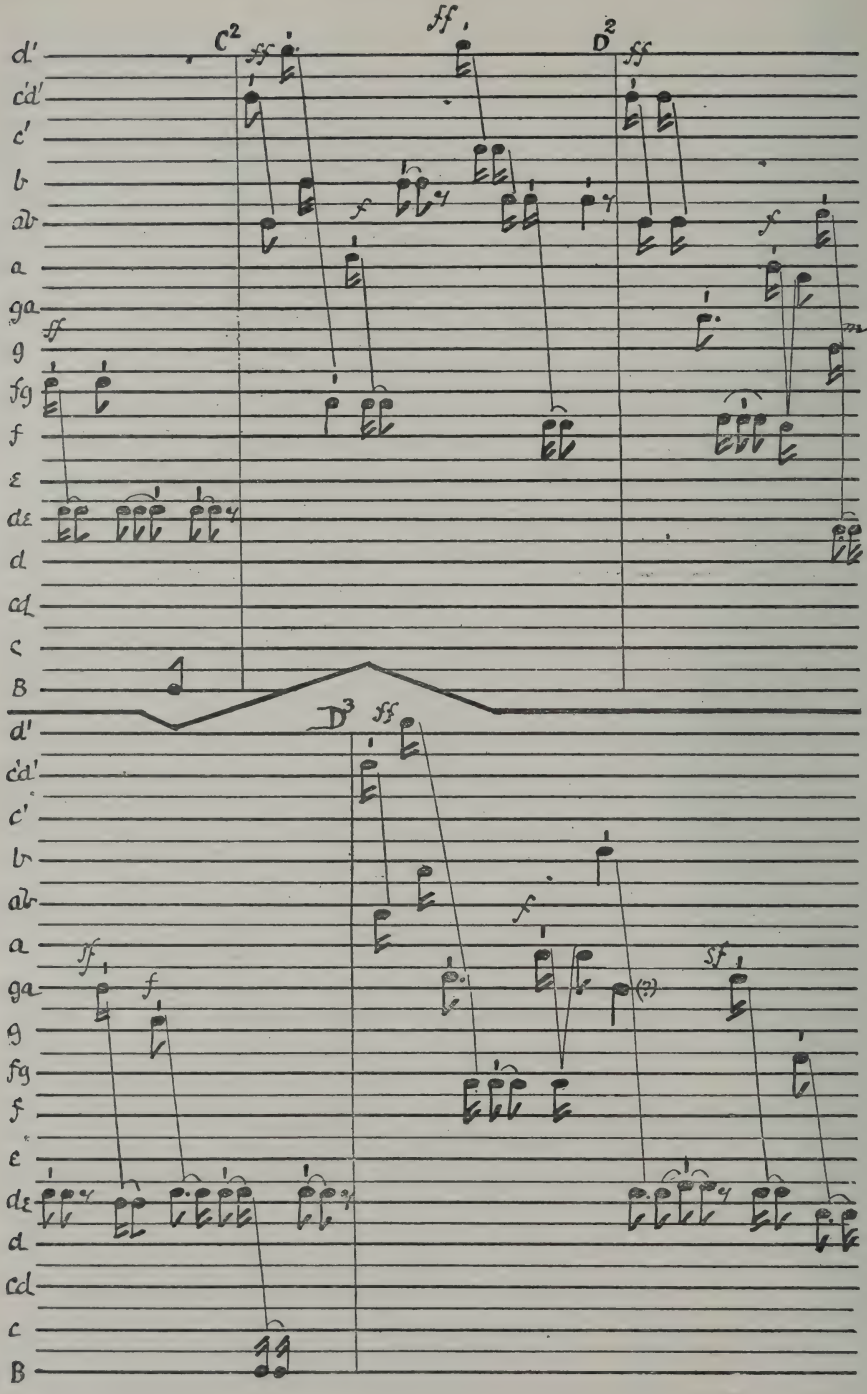


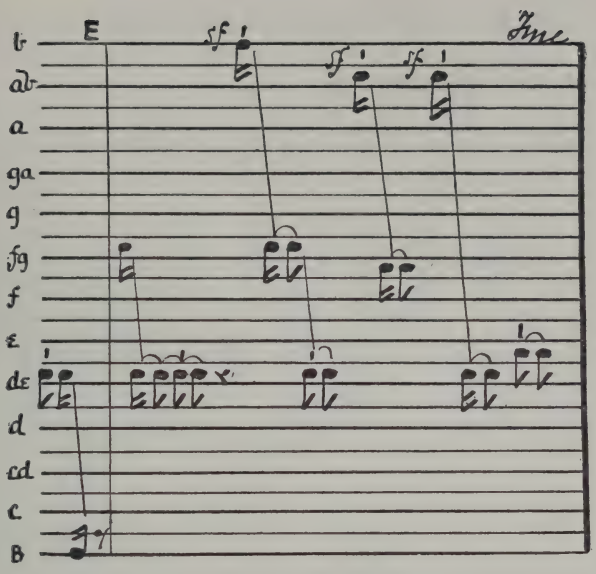
(IX) ÇO-YÓ-HIM KATCINA. CYLINDER XXVI at 167 r.

♩ = about 75. Scheme of record A'B'B²'C'D'C²D²D³E

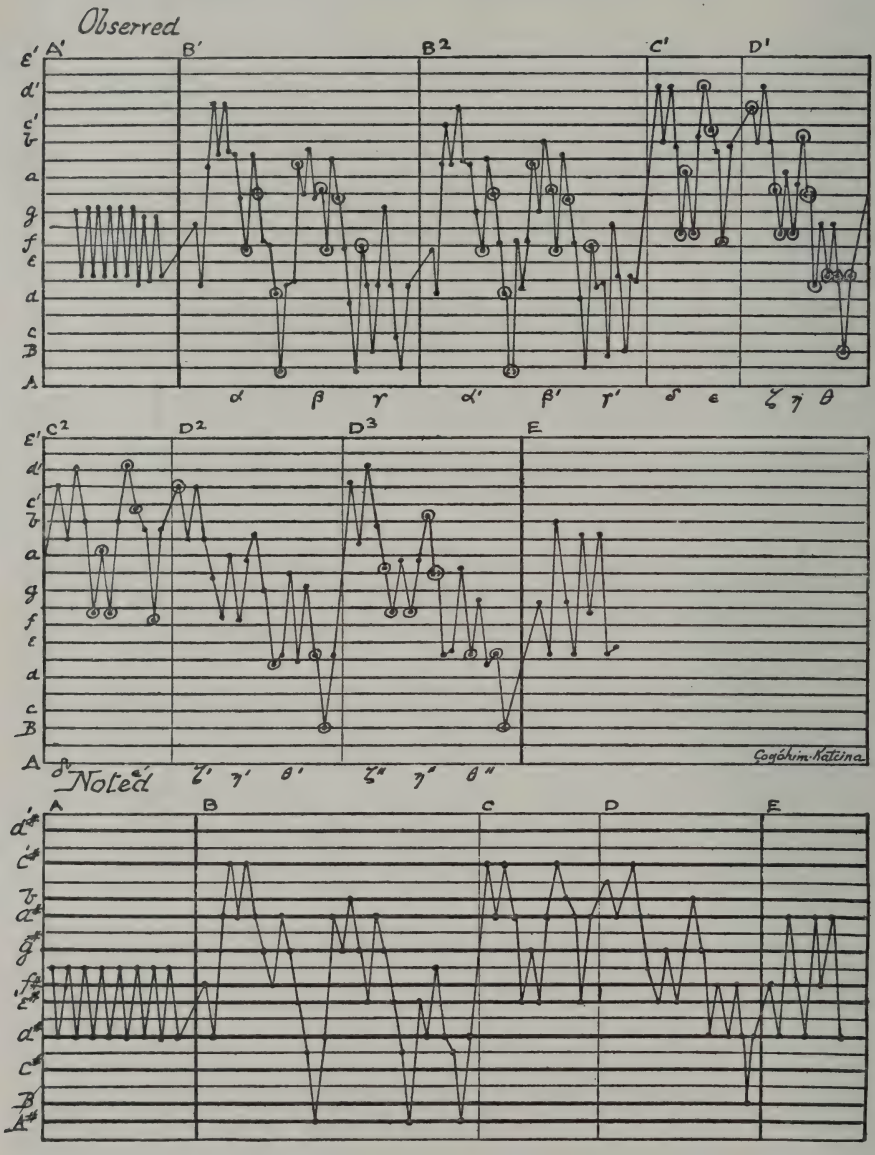



B²
c'd'
c'
b
ab
a
ga
g
fg
f
ε
dε
d
cd
c
B
AB
d'
c'd'
c'
b
ab
a
ga
g
fg
f
ε
dε
d
cd
c
B
C'
D'
f
ff
m
p
accel.
primo tempo
(?)


C2
D2
D3
ff
fff
f
sf
d'
cd'
c'
b
ab
a
ga
g
fg
f
e
de
d
cd
c
B


E
sf
sf
sf
Fine

COURSE OF TONE: ÇOYÓHIM-KATCINA



ARGUMENT. A minor third (fg–de) introducing an augmented tetrad (c′d′–ab–ga(g)–f) surmounting a major triad (f–d–AB) is by degrees depressed into the triad and by degrees returns, bringing the triad, to its initial pitch (fg–de–B), to which the tetrad also eventually accommodates itself (d′–b–a(ga)–fg).

THIS song is exceptional in its level course (compare Snake Song No. 1, Jakwaina, and Anonymous I and II), most of the series sharing the downward movement of Malo-katcina. It further differs from that song in presenting in the three chief segments B, C, and D, a number of different motives. A reiterates a major third becoming minor, by way of introduction; B presents a motive (α) within an augmented tetrad over a major triad, repeating it with the first few intervals changed (β) and following it with a coda (γ) approximately rehearsing the triad; C presents another or more properly two (δ and ϵ) confined to the tetrad shifted upward an approximate semitone; D three more (ζ, η, θ), the second and third alike and of coda form, leading back to the triad of B; E presents notes outlining the main tracts occupied by the melody.

These motives are connected and repeated with a shift and play of fabric both noteworthy and novel in type. In the coda (γ') of the second B the triad suddenly rises a semitone, its mediant becoming de+, the pitch of the introduction A and finale E, instead of de– as in γ. Thereupon in the first motive of C the tetrad field likewise rises a semitone, extending itself downward again in the second motive, ϵ, returning to the higher level in ζ of D^1 and connecting with the raised triad in θ. C^2 repeats this process nearly identically as the circled notes show, apart from a zigzag ascent that recalls the old level; and is followed by two D's, both executing the triad at the higher level (fg(g)–de–B), but D^2 executing the tetrad within the lower, D^3 within the higher field. E adds its epilogue by indicating the fifth and the minor sixth hence occurring in η' and η'' respectively, together with a suggestion of the resulting compressed and full forms (γ') of the minor third (fg)f–de.

This same minor third was the introductory interval of the whole

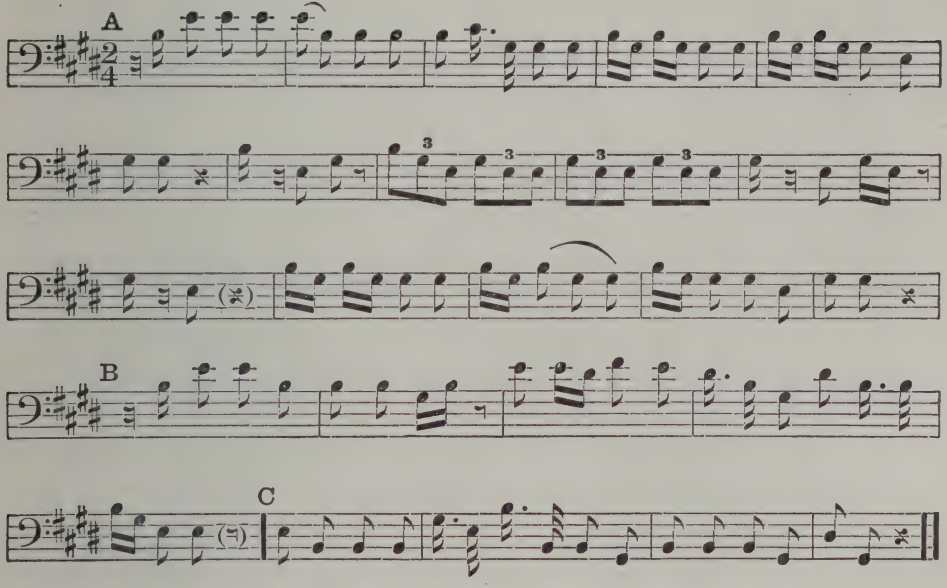
melody, after a long rehearsal as a major; and its reappearance in D^3 is its final reassertion after reduction to a tone (γ), descent of a semitone (α'), reappearance as a tone, and restoration to the original pitch (γ'). The villain of the piece is not far to seek. The tritonus familiar in previous songs presents itself at the moment of both these changes; in the first descent of γ preceding the semitone subsidence in B^2 of the initial minor third, and in the first descent of γ' preceding its reappearance bringing the triad up with it. The quarter tone yield and reaction of the axial note, de+, to and from de−, is nearly synchronous with the subsidence and reappearance of the third, and may be conceived as sympathetic in origin.

In general character the melody is a lusty minor, the prominence of the minor third adding zest to its vigorous and peculiar rhythm. The unaided ear recognized that the motives of B were adiatonic in structure (outlining a fourth between two minor thirds), and the fact is expressed in the staff notation. But by neglecting in the C's and major D's, D^1 and D^3, the semitone rise of the tetrad while remarking that of the triad, the ear brought these segments within diatonic limits. The alteration of the first and last trichord of B^1 (ab–ga–f, de–c–AB) to forms more familiar to the diatonic consciousness (f being heard as fg, c as d) further evidences the power of musical thought to nullify in rapid observation the plain and even repeated evidence of sensation.

As in Malo-katcina, numerous homologous notes judged at the same pitch bear testimony to extraordinary virtuosity in the performer. In the D's he three times reaches the identical de+ by movements twice spanning a minor sixth and once a fifth, as one might vary one's steps down a familiar trail to the same rock.

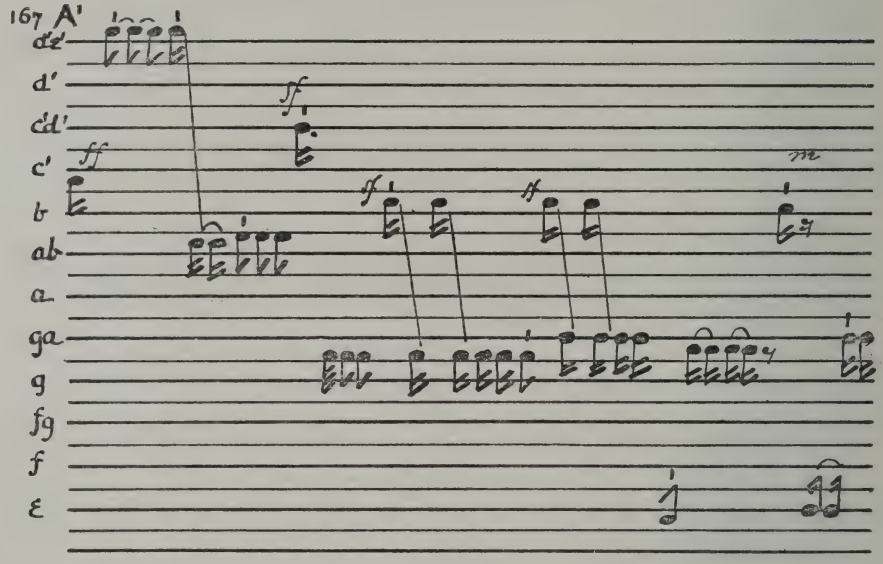
SHIASHTASHA

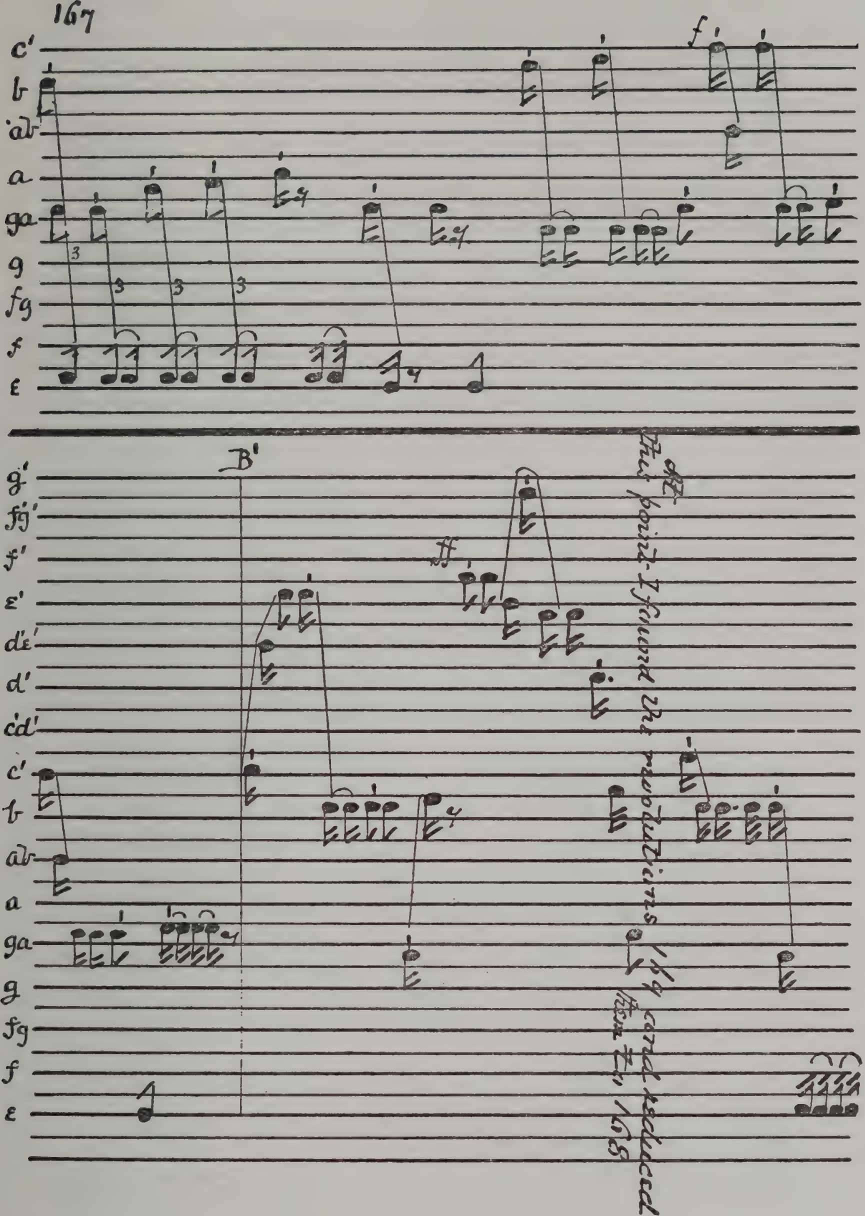
BY SINGER NO. 1 AND SINGER NO. 2

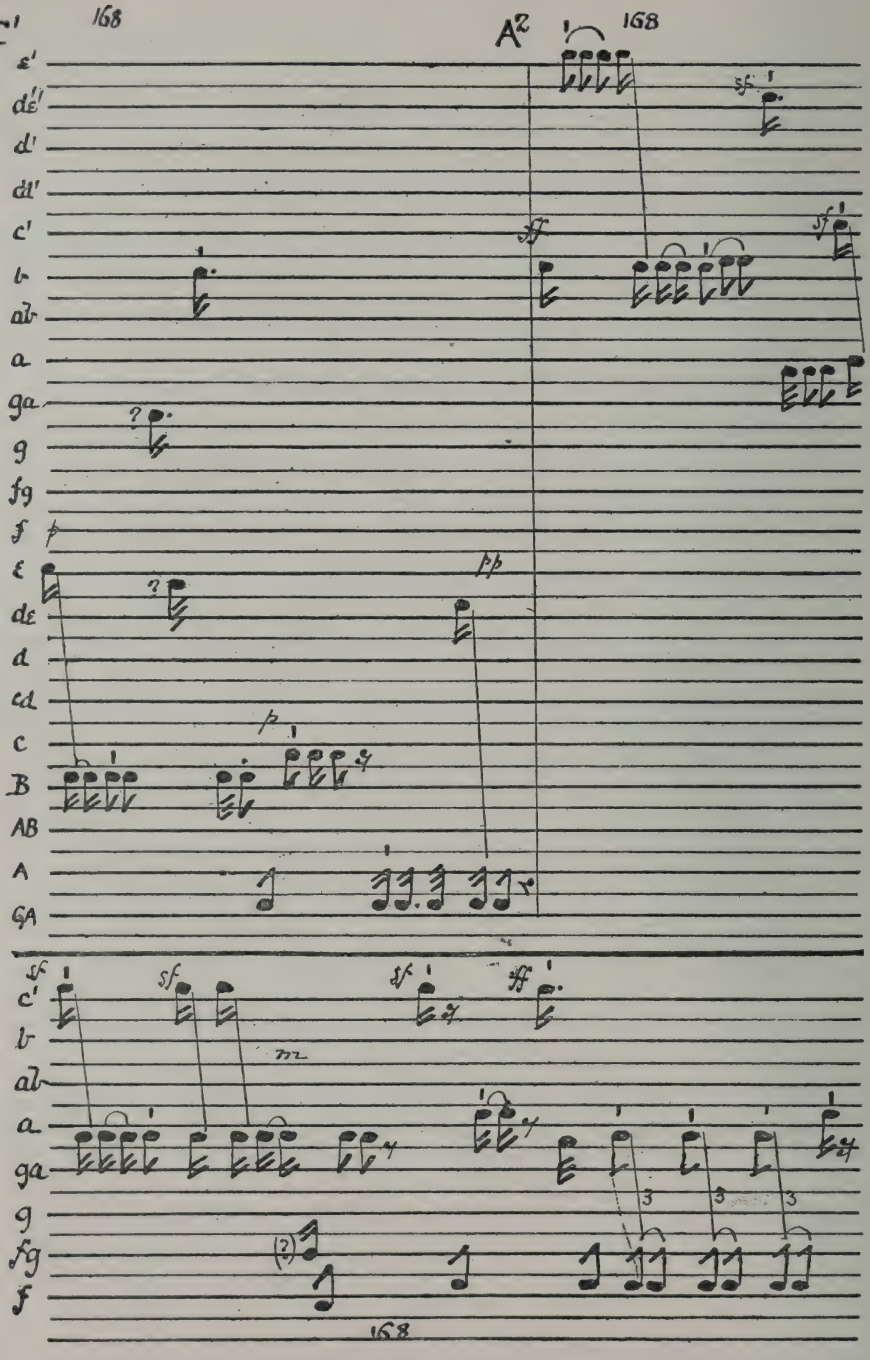


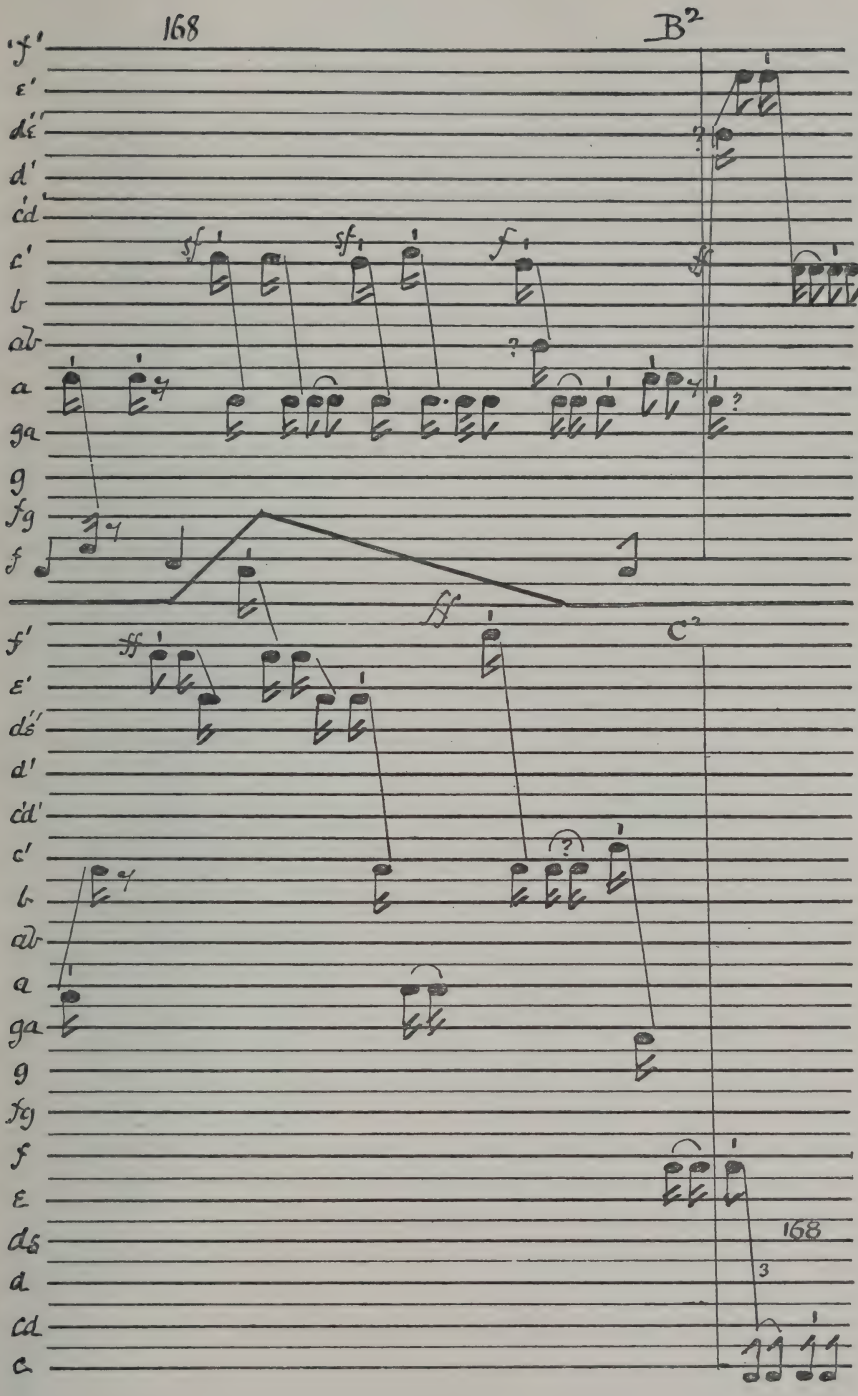
(X) SHIASTASHA by Singer №1. Cylinder VIII.

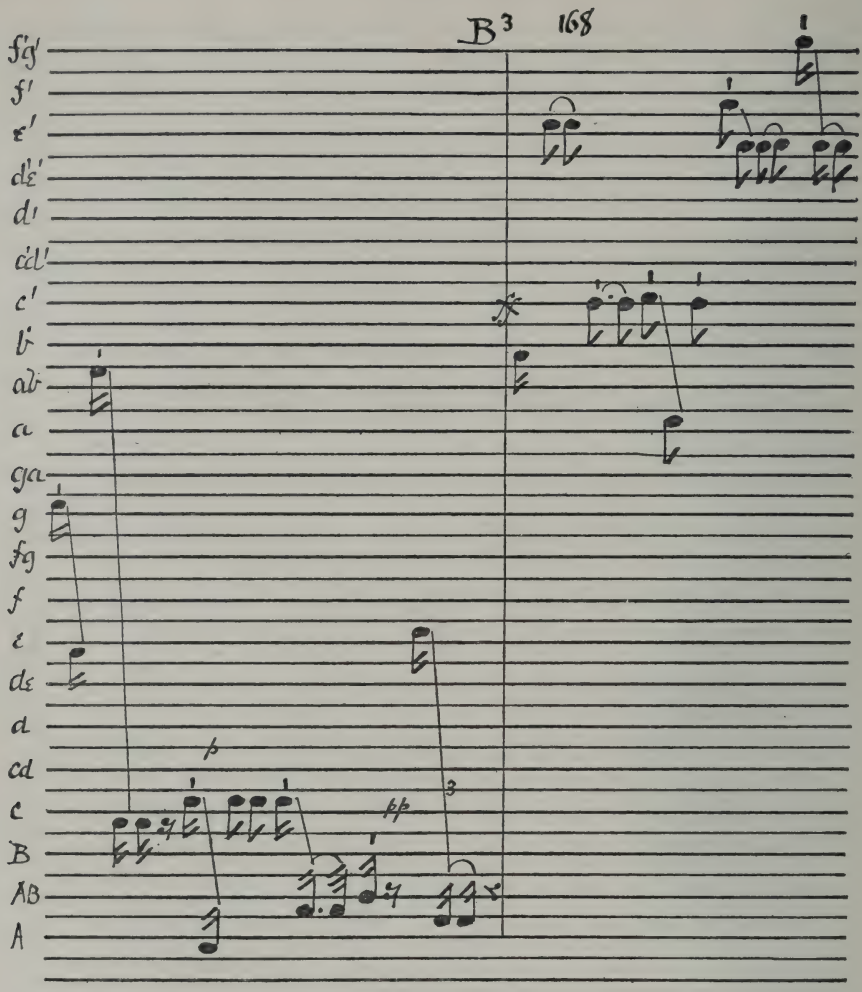
♩ = 80 Scheme of record. A'B'C' $A^2B^2C^2$ B^3C^3.

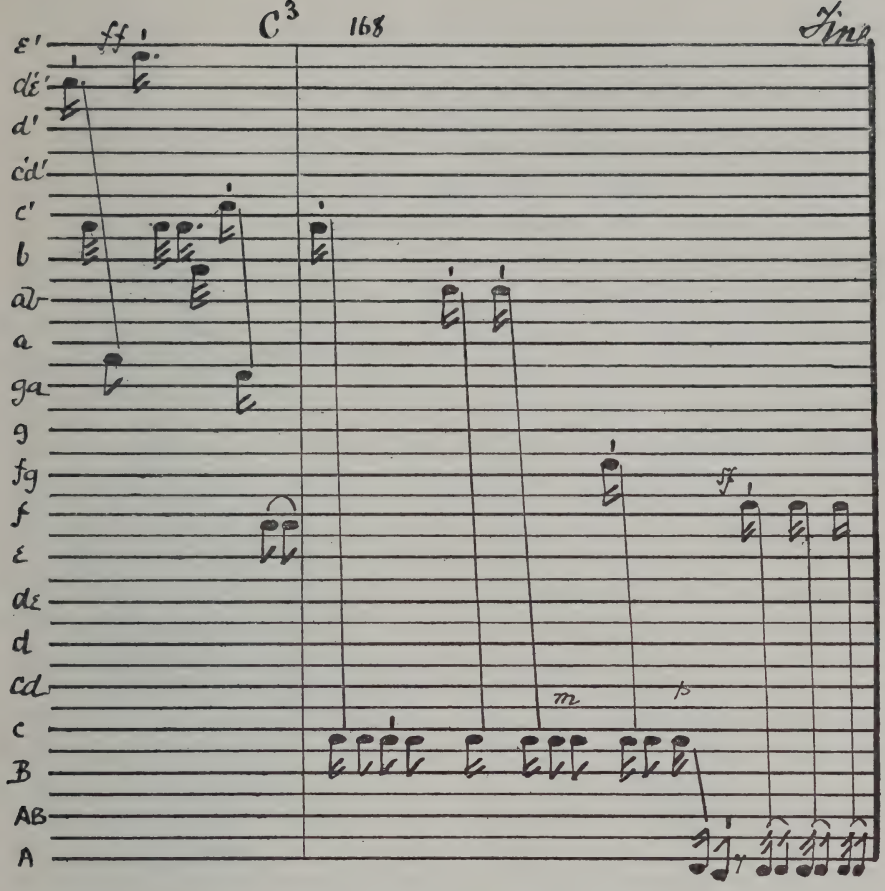



167
B'


C'
168
A2
168
168


168
B²
C²
168
3

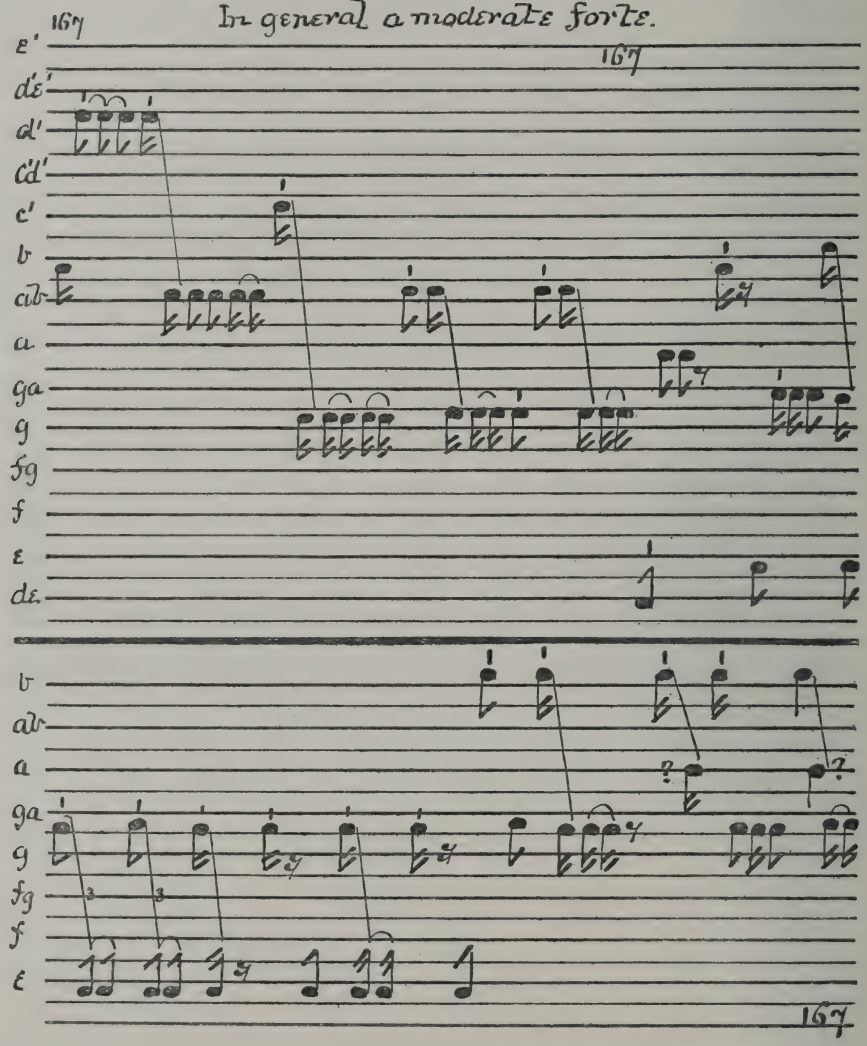

B3 168
fg'
f'
e'
d♭'
d'
c♯'
c'
b
a♭
a
g♯
g
f♯
f
e
d♭
d
c♯
c
B
AB
A
p
pp
3

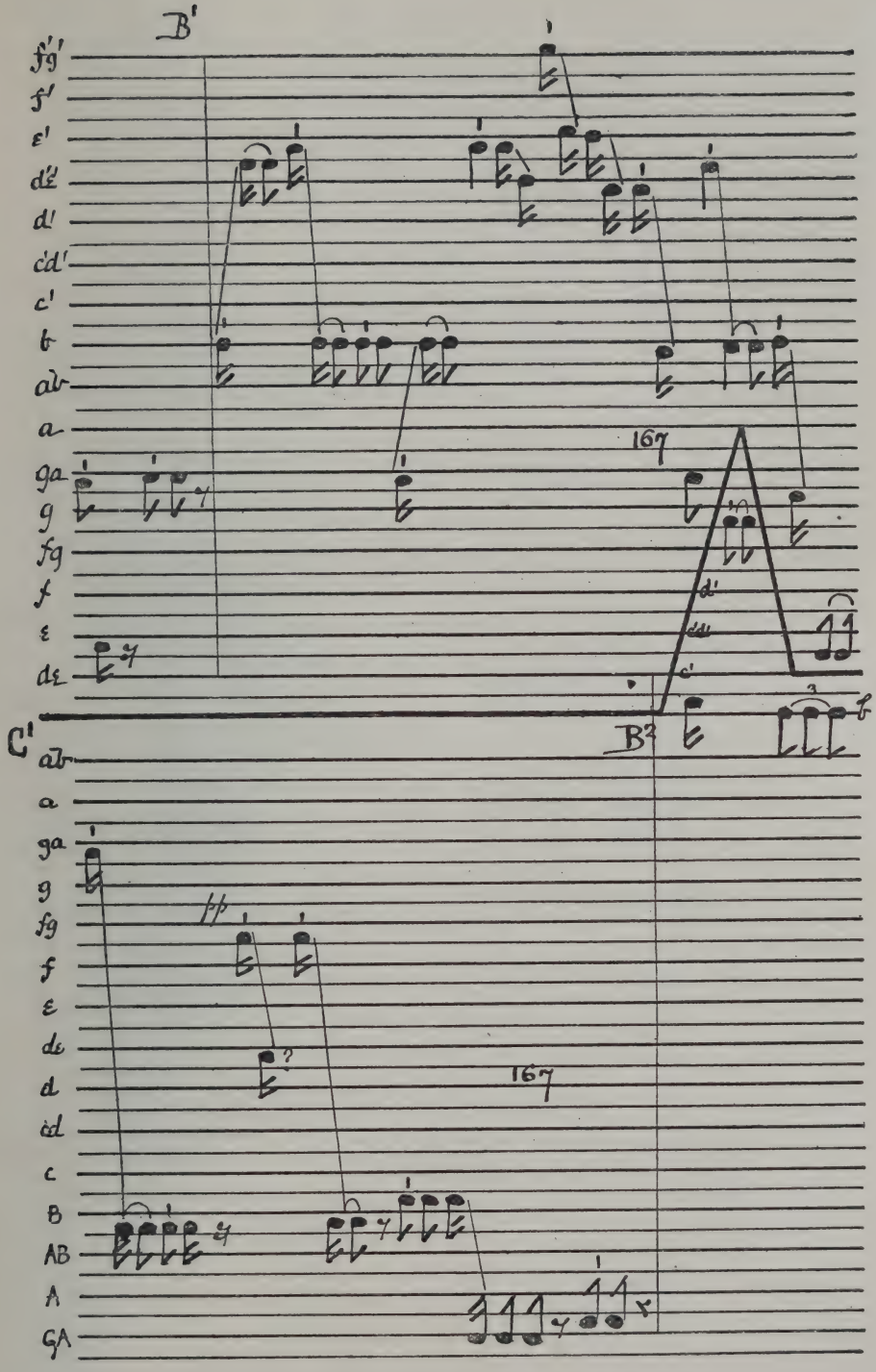

C3
168
Fine
ff
ff
m
p
ε'
dε'
d'
cd'
c'
b
ab
a
ga
g
fg
f
ε
dε
d
cd
c
B
AB
A

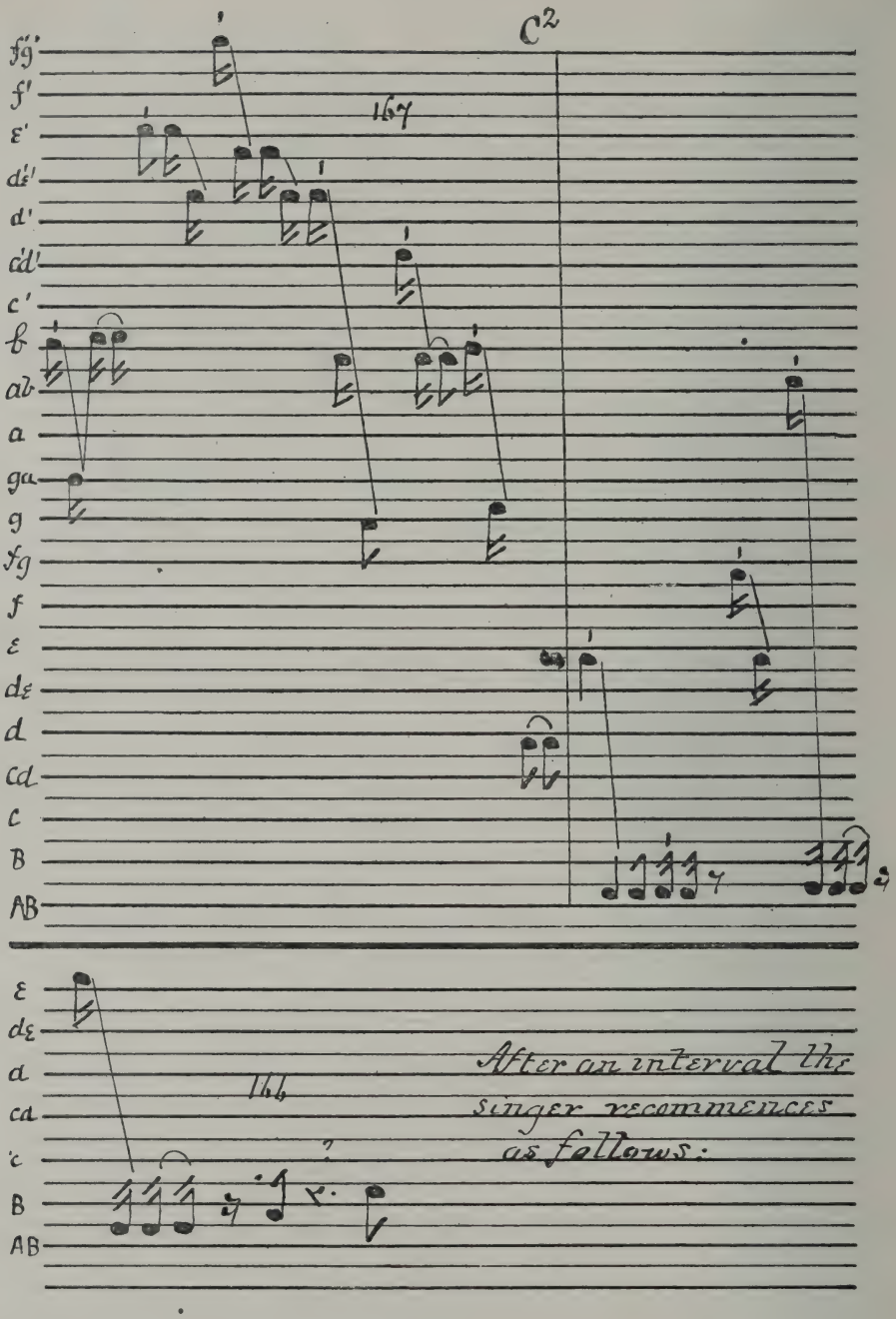
(XI) SHIASHTASHA by Singer № 2. CYLINDER II

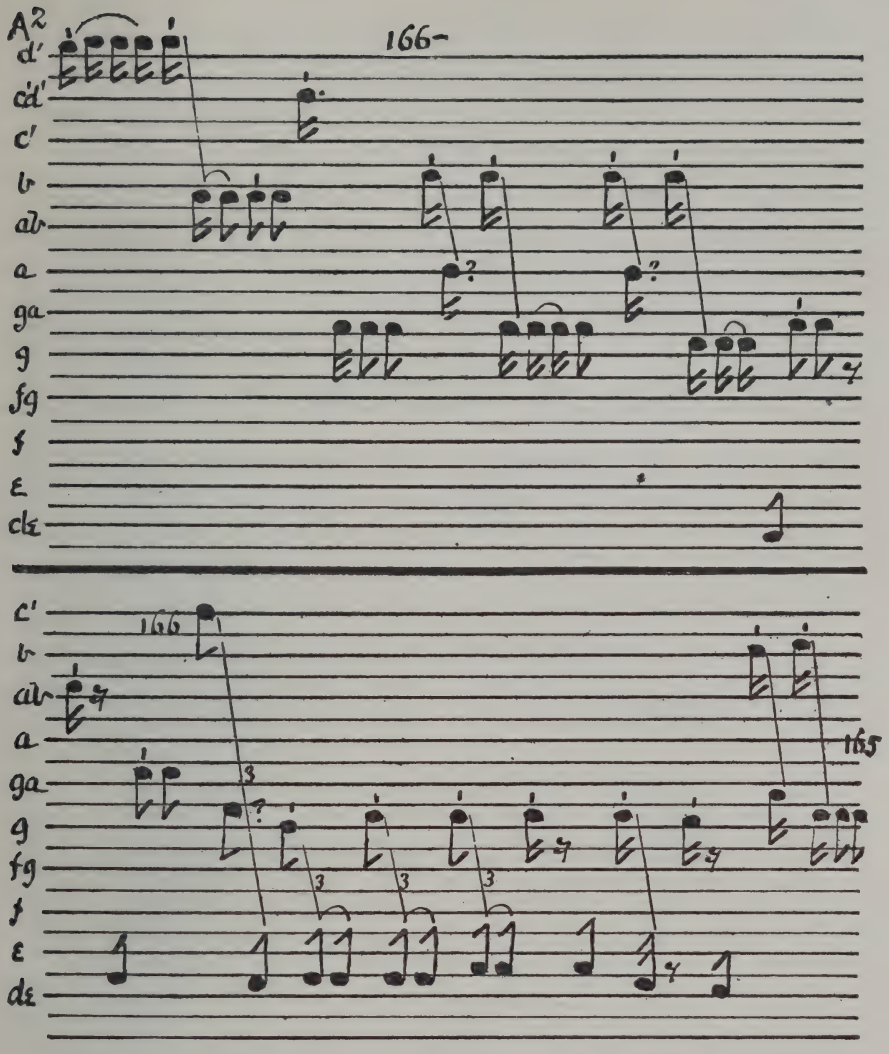
♩ = 80+ Scheme of record $A^1B^1C^1B^2C^2 : A^2B^3C^3A^3B^4C^4$

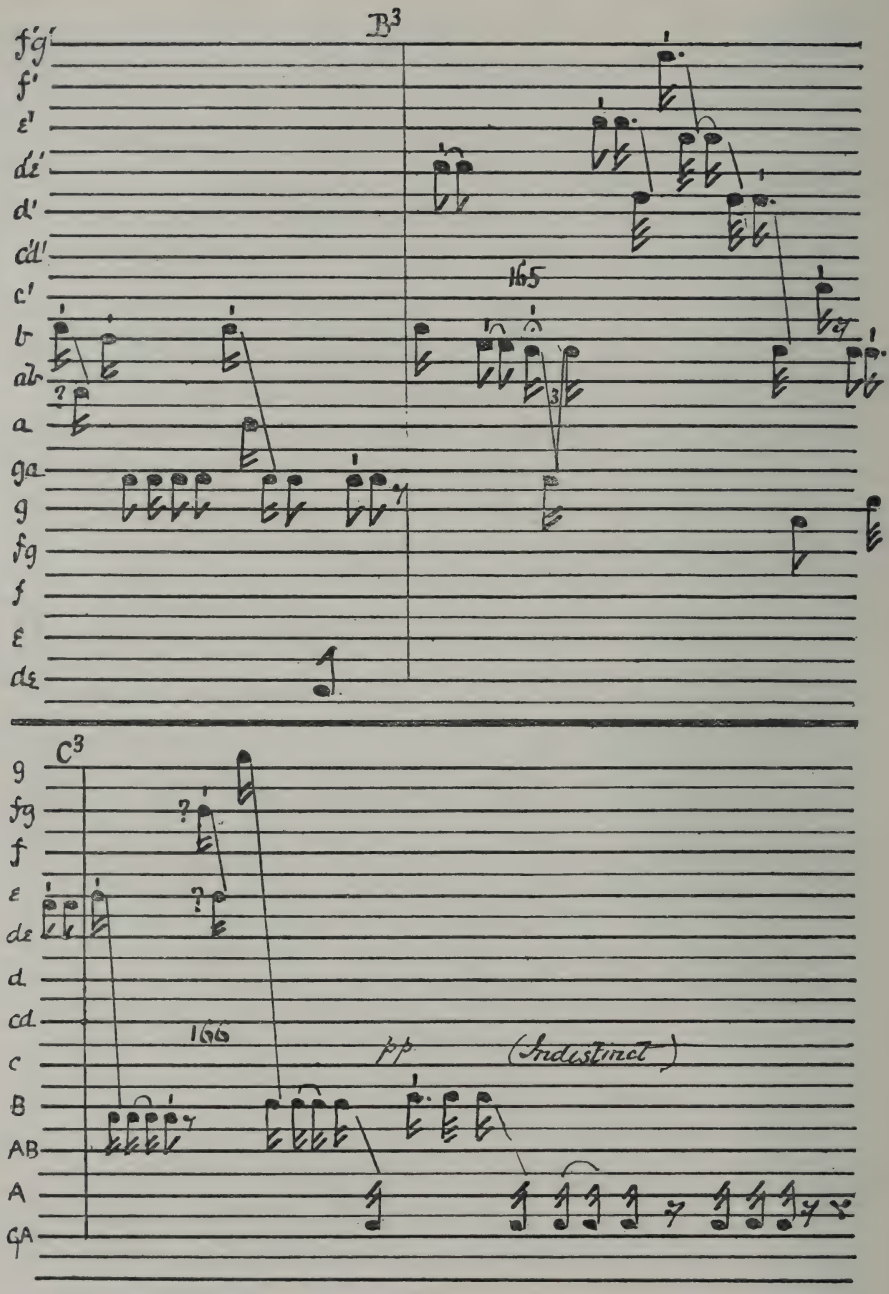
In general a moderate forte.

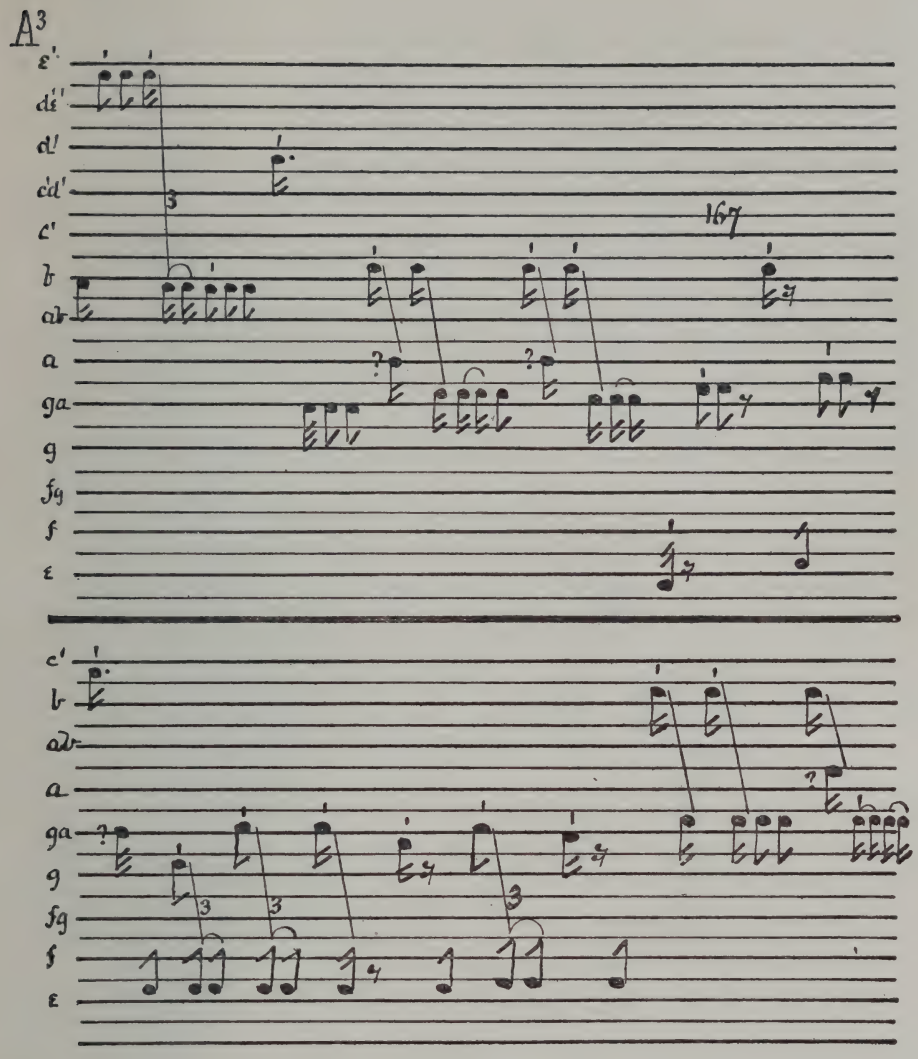


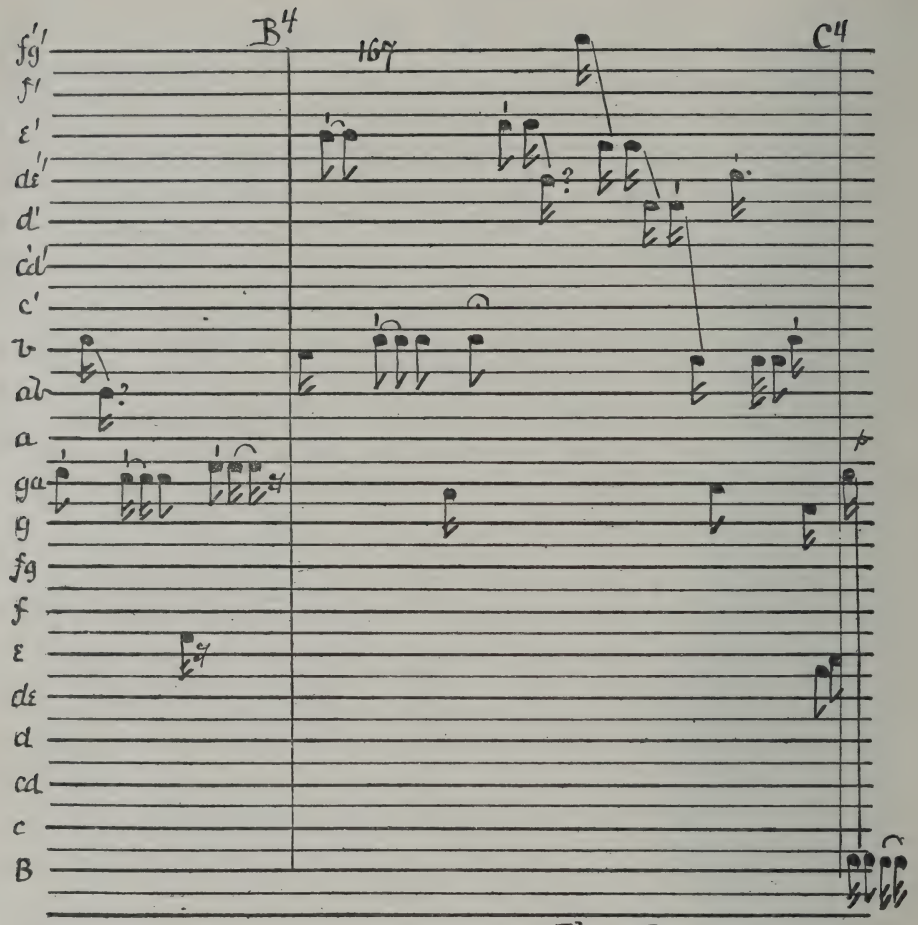

B'
167
B²
C'
167


C2
167
166
After an interval the singer recommences as follows:

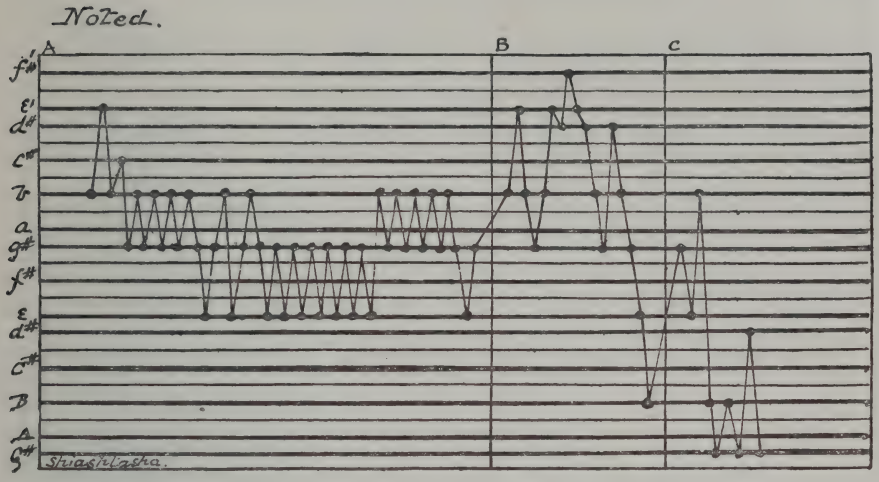

A2
166-
166
165


B3
165
C3
166
pp
(Indistinct)


A3
167


B4
167
C4
The cylinder ended here. Revs 167.

COURSE OF TONE: SHIASHTASHA

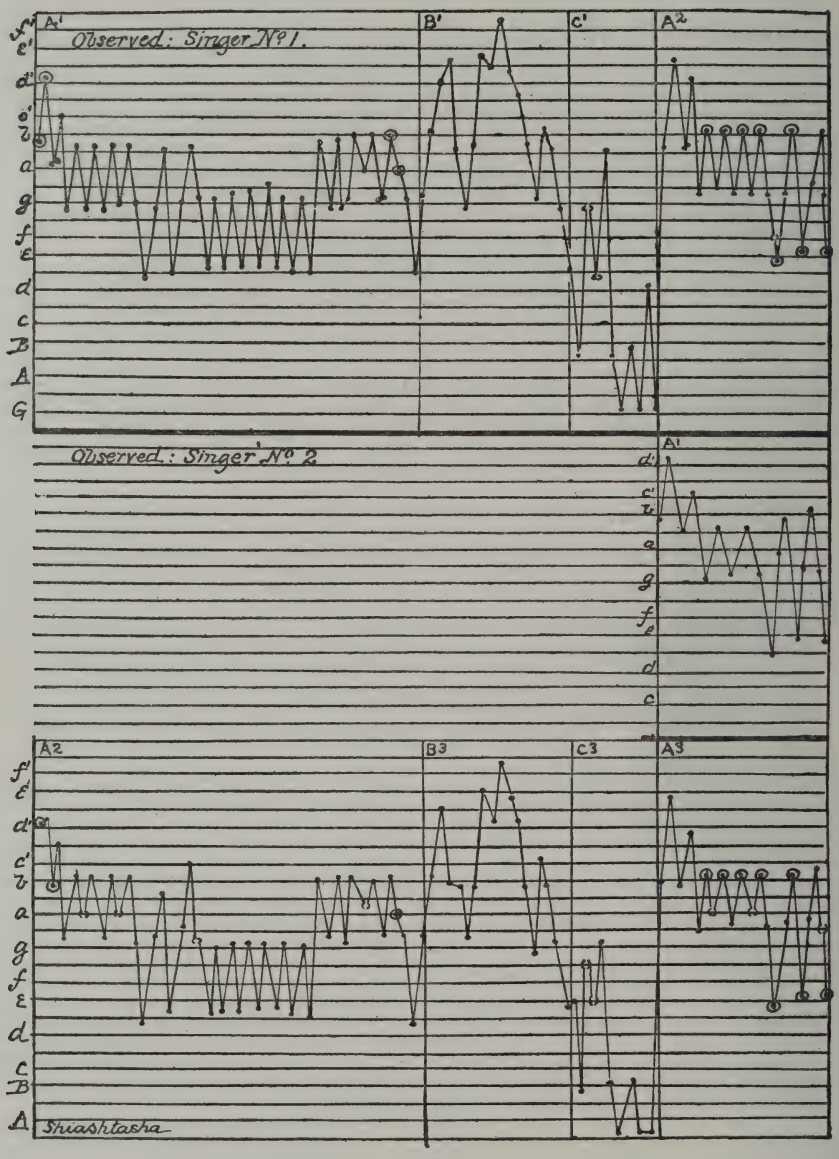


(For the observed course of tone, see the following two pages.)

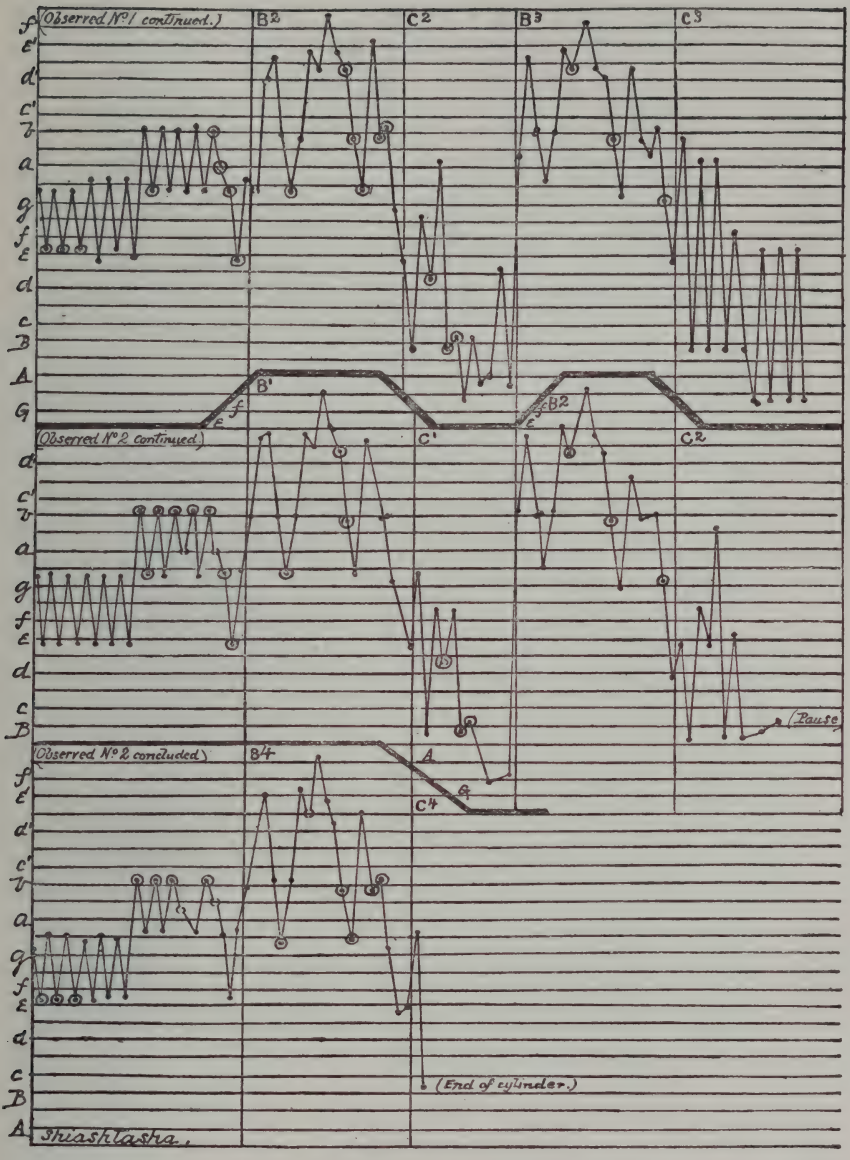
ARGUMENT. A triad (d′–b–g : with other mediants) identifies with its extremes the mediants of two major triads superposed (f′–d′–ab, ab–g–de), and becoming alternately major and minor upon a mediant (b) constant but for a simultaneous change of a quarter tone, raises and lowers them accordingly.

THE plasticity of fabric characteristic of this music presents itself in a new guise in this song. The performance of each singer consists of repetitions of a triple strophe exhibiting two well-marked types, a major and a minor version, differing in internal relations of pitch and, as in the last song, by a quarter tone variation in the intonation of an important note. The first singer begins with the minor version, and, following it with the major, repeats the close with changes toward the minor version, which give this addendum the aspect of a connecting link. Such a link it becomes in fact in the performance of the second singer, who begins with the major version, repeats its close with like changes, and after a pause recommences with the minor version and proceeds with the major until cut short by the end of the cylinder.

COURSE OF TONE: SHIASHTASHA



COURSE OF TONE: SHIASHTASHA, CONCLUDED



Symbolically expressed, the illustration of the cycle given in the three performances is as follows: —

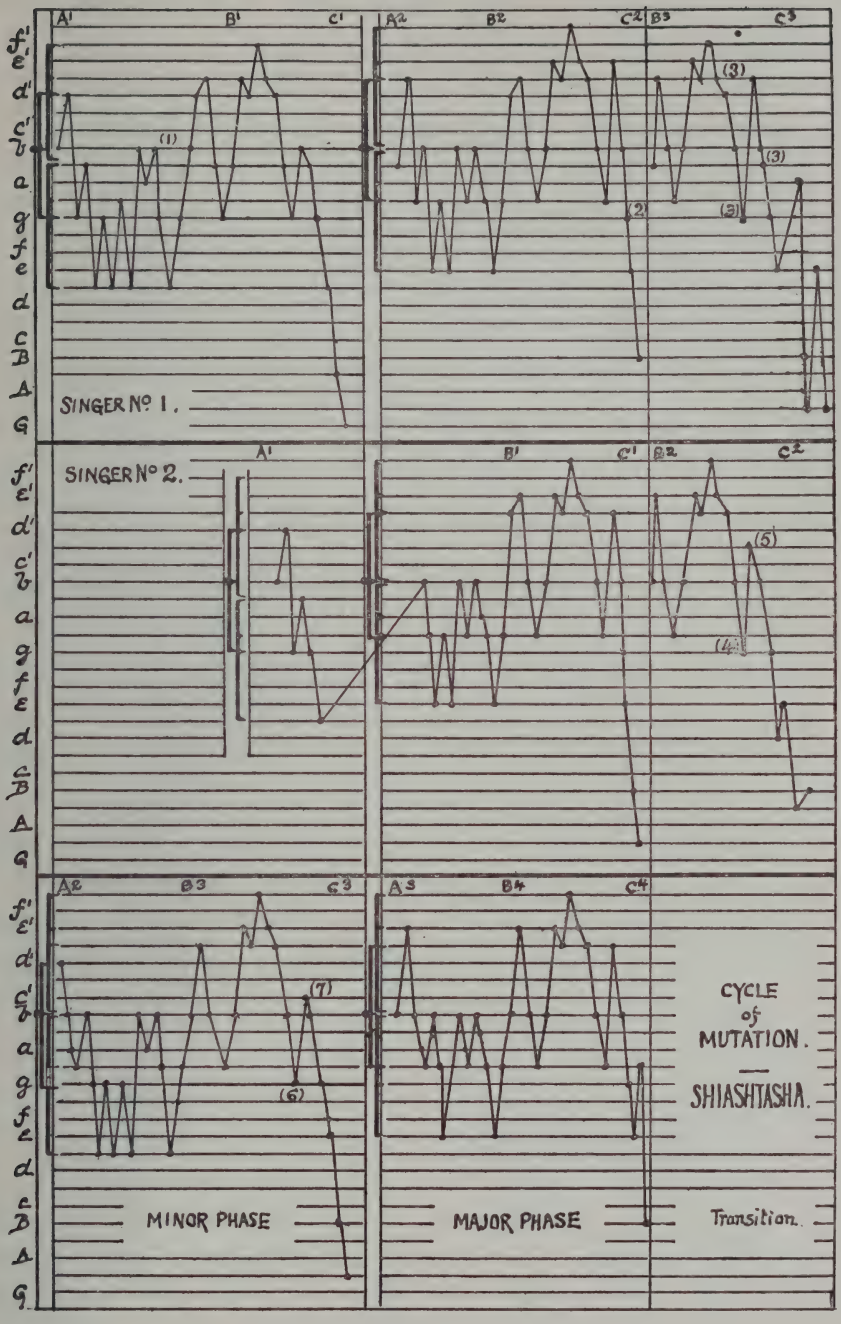
1st Singer. A.B.C. (Minor) — A.B.C. (Major) — B.C.

2d Singer. A.B.C. (Major) — B.C.

A.B.C. (Minor) — A.B.C. (Major) —

In A two salient movements outlining a triad (introductory) descend to a movement in a major triad (triad of A) whose mediant is the base of the first and which tends to become a tetrad by the division of the upper interval. Upon this major triad B erects another whose mediant is the summit of the first and which tends in the same way to become a tetrad. C emphasizes the lower octave of the summit of the A triad and generally that of its mediant also, among other pitches touched.

The superposed triads — the main field of A and the field of B — are both major; but that of the introductory movement is made by both singers alternately major and minor. This change with its result upon the remaining texture constitutes the distinction between the minor and major strophes. The mediant of the introductory triad is constant throughout both performances, excepting that when the extremes fall through the approximate semitone that makes the triad major it too falls about a quarter tone, recovering its pitch when they rise to make the triad minor. The accompanying diagram of the cycle of strophes presents more intelligently than can language the alternately looser and closer, minor and major, connection between the tracts occupied by the main movements of the song.


SINGER Nº 1.
SINGER Nº 2.
MINOR PHASE
MAJOR PHASE
Transition.
CYCLE of MUTATION.
SHIASHTASHA.

The performances diverge as follows from the schematic cycle: Singer No. 1 gave all of the notes of his opening strophe a pitch which refers them to the relaxed (minor) version, excepting those marked (1), which unequivocally took the major level. He opened his major strophe with the junction pitch (ab) of the minor version; but the pitch of note (2), while that of its minor homologue, is that of all the other homologues as well, the A triad changing to minor in the major B's at this point. The modification in the following repeated B^3, which seems to betray thoughts of a coming relaxed performance of the strophe, affects the notes marked (3), all of which are lower than their preceding homologues. The variation in pitch of the highest notes in the different B's indicates that they were at the limit of the singer's voice and renders any theory of their intent less certain. The third C is developed by this singer as a finale. It reflects the major fabric, excepting that the note B which took both major and minor levels in the foregoing C is here pitched unequivocally at B.

Singer No. 2 also begins his performance in the minor phase, but has only just completed the A triad when he reverses his conception of his place in the song, and through the remainder of the strophe adheres consistently to the more vigorous reading. In the following repetition of B C he gives three signs of a coming relaxation: the lowering of note (4) the smaller rise at (5) and the reiterated note AB. He follows No. 1 in the first and approaches the minor version still more closely in the second; while the note AB is the octave of the junction pitch of the minor version. In beginning this after his pause he follows Singer No. 1 and his own original start in giving his introductory triad the minor level, making its mediant b−, and in performing the lower interval of the A triad in the minor version. But the upper interval and most of the rest of the strophe he raises to the major level. The two halves of the A triad hence part company, B^3 reverts to the minor form only at the note marked (6) and in the characteristic minor timidity of the rise at (7), and C^3 only in the initial note B−. The final major strophe is performed consistently in the vigorous form and ends on

the lower octave of the initial note of the song, raised through precisely the quarter tone by which both singers emphasize the distinction between strophes minor and strophes major.

All three performances are less regular than some of the other songs, yet exact coincidences between them are not infrequent, as the circled notes show, and close approximations are numerous. In the diagrams of the observed course the level of the actual performance of No. 1 has been lowered a semitone to facilitate comparison with that of No. 2 by giving the initial note of each the same pitch. It cannot be by chance that in the final descent of the first and third major B's (B^2 of No. 1 and B^4 of No. 2) both singers shift from the pitch of their opening notes (actually different pitches) to the quarter tone higher level which in the song of each has since represented it; and that in the remaining major B (B^1) No. 2 strikes intermediate pitches, in the C immediately following copying No. 1 in reflecting the identical shift b− to b+ in the octave below. These coincidences argue in both performers a notable musical endowment, — delicacy of ear, tenacity of auditory memory, and pliancy of voice.

Beside ignoring the non-diatonic (minor) version of this song, the staff notation missed the melodic point of that it chose. Extending the span of the introductory movement to a fourth above the A triad it changed the melody from a combination of fifths to a division within an octave. The musical thought in which the contrast between the strophes has its seat was obscured from the start, the unchangeable fourth (e′–b) usurping the place which the singers had given the mutable third. Note (2) is adiatonic in the major version and its retention on the interior pitch of the A triad was the only specific recognition accorded by the ear to the minor version. Here as elsewhere the ear noted and enjoyed a game flavor in the performances which it was impossible to imprison in the staff notation.

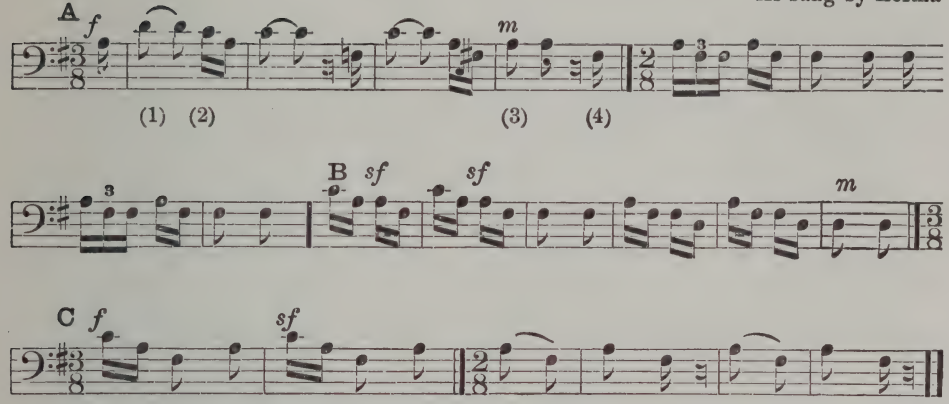
Codas like the C's of the present song, consisting mainly of leaps at one or two important notes, add their item of evidence against a scalar interpretation of this music; for it is in their finales that

European compositions display the empty scale in reiterations of the tonic, dominant and subdominant triads. Likewise the end of a play leaves the audience of a theatre with the framework of the action, but an audience *al fresco* with the performers themselves.

ANOSHKAEY

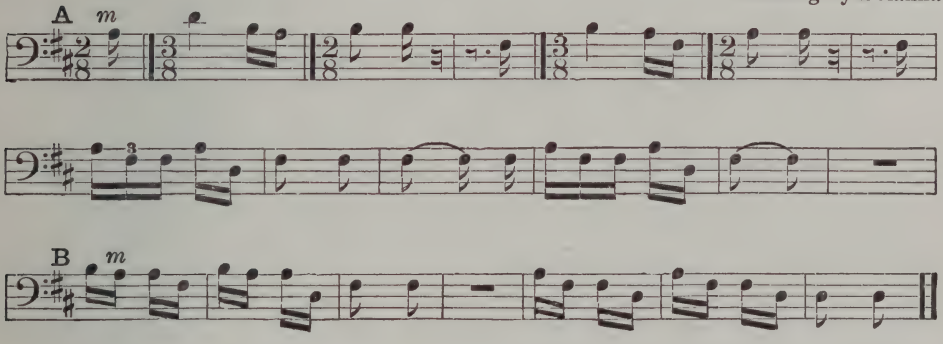
BY LESMA AND BY POLAKKA

As sung by Lesma



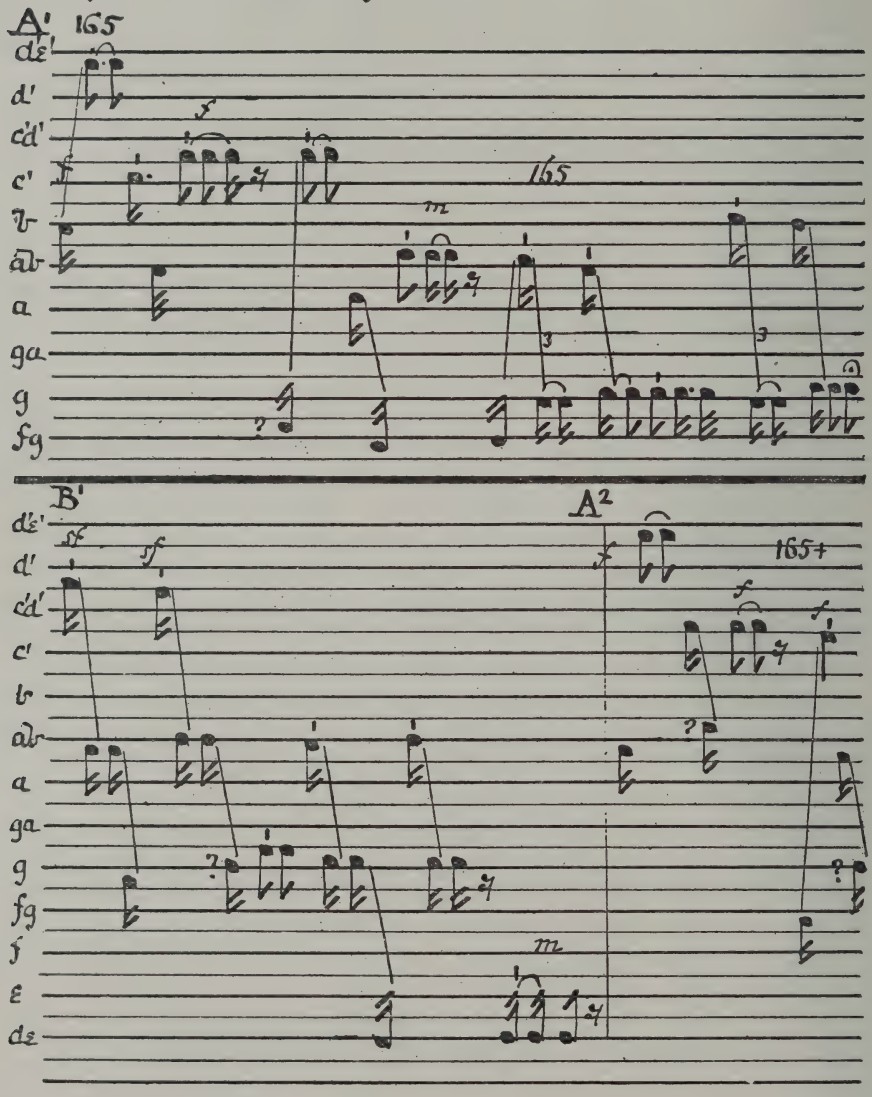
(1) or c′♯ (2) or b (3) or a♯ (4) or **f**.

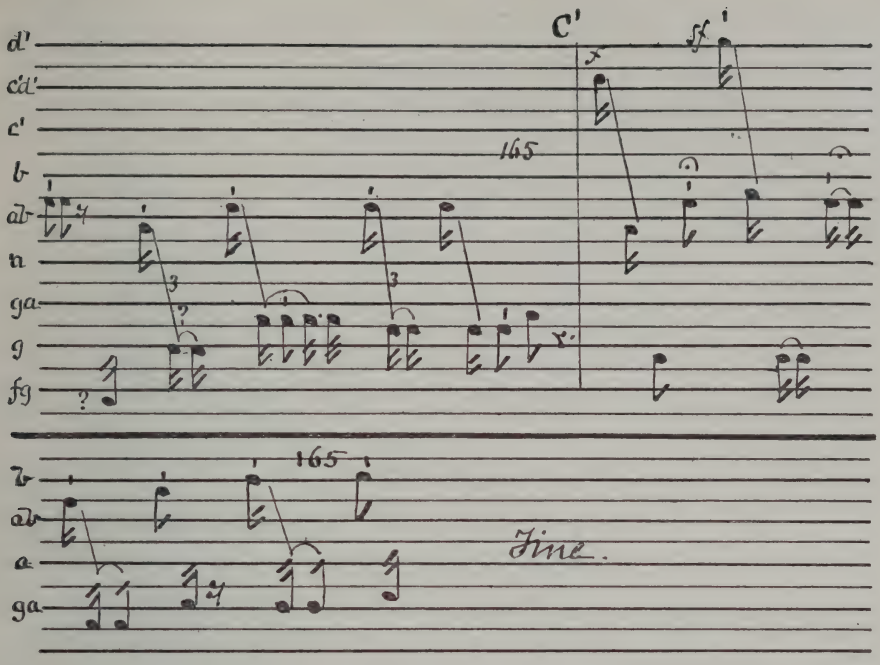
As sung by Polakka



(XII) ANOSHKAEY sung by Lesma CYLINDER IX

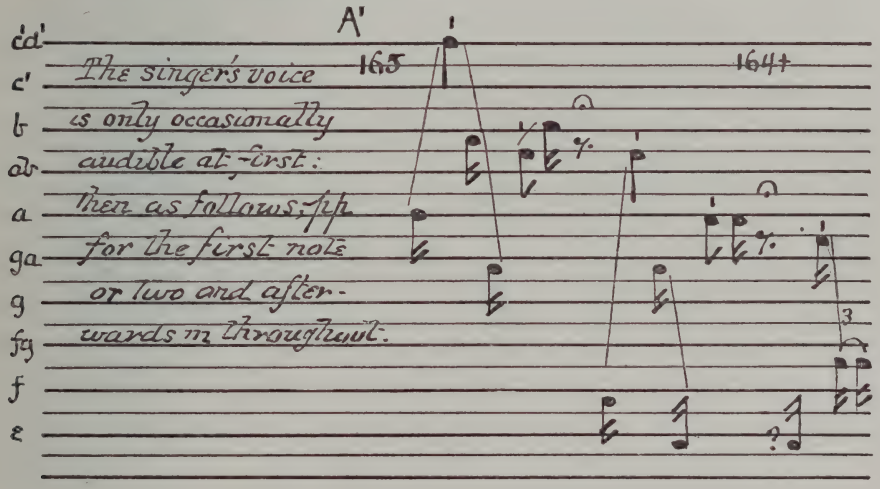
♩ = 70 Scheme of record A' B' A² C'

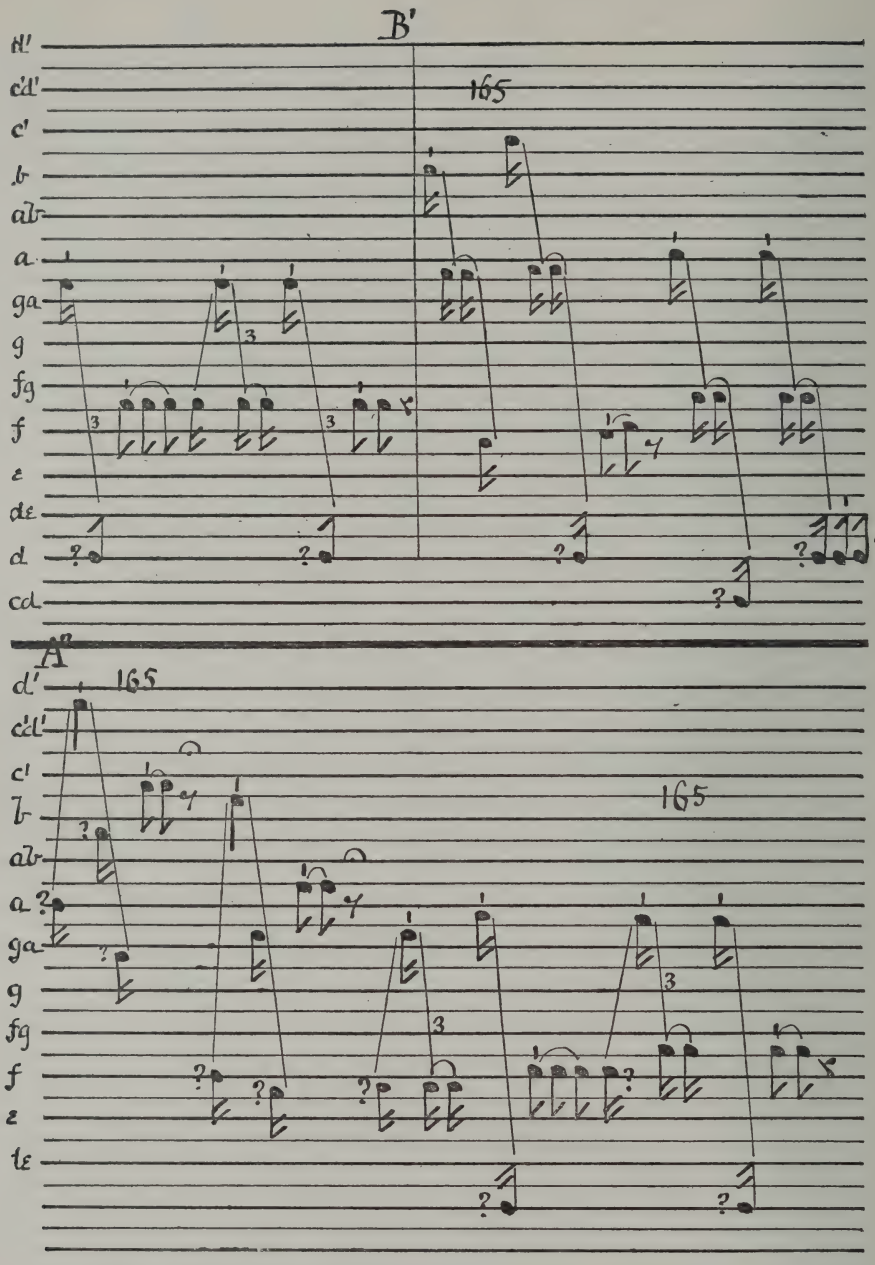


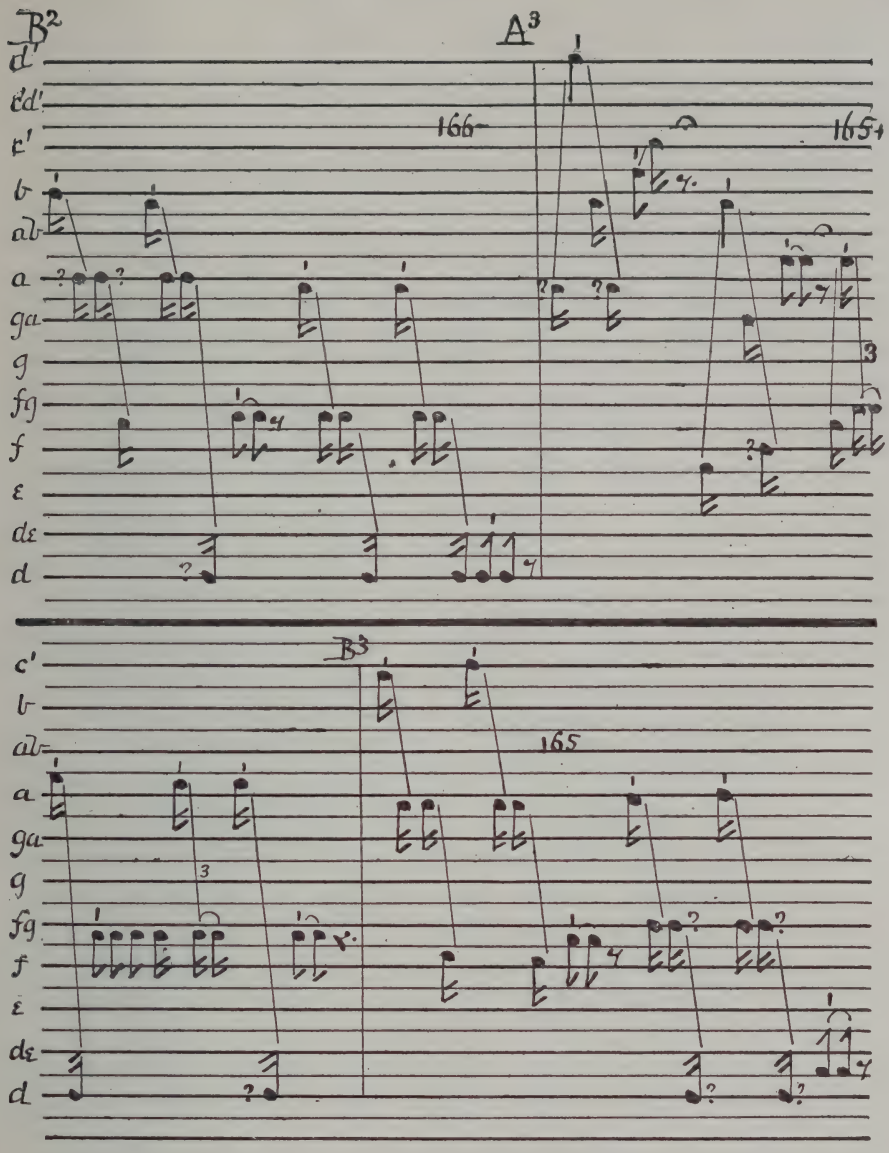


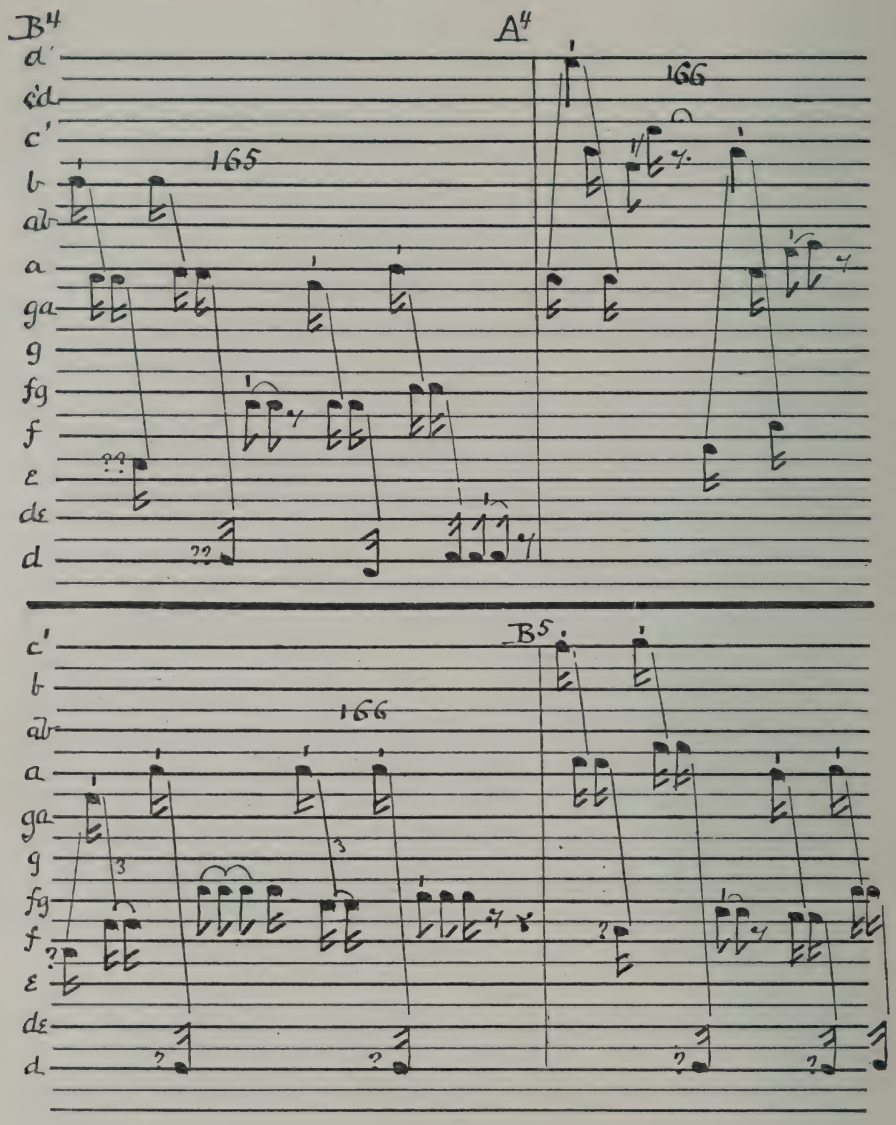
(XIII) ANOSHKAEY sung by PolaKKa. CYLINDER XV.

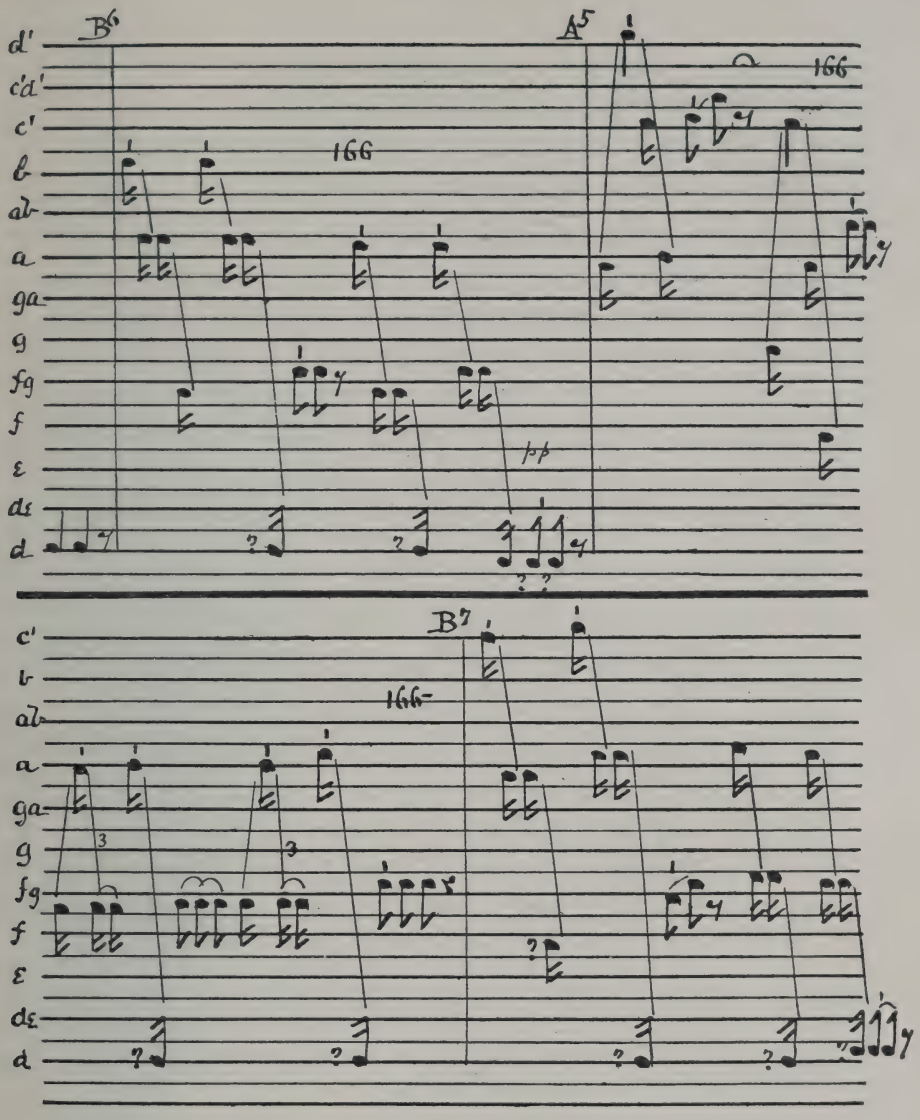
♩ = about 80. Scheme of record A'B'A²B²A³B³B⁴A⁴B⁵B⁶A⁵B⁷A⁶

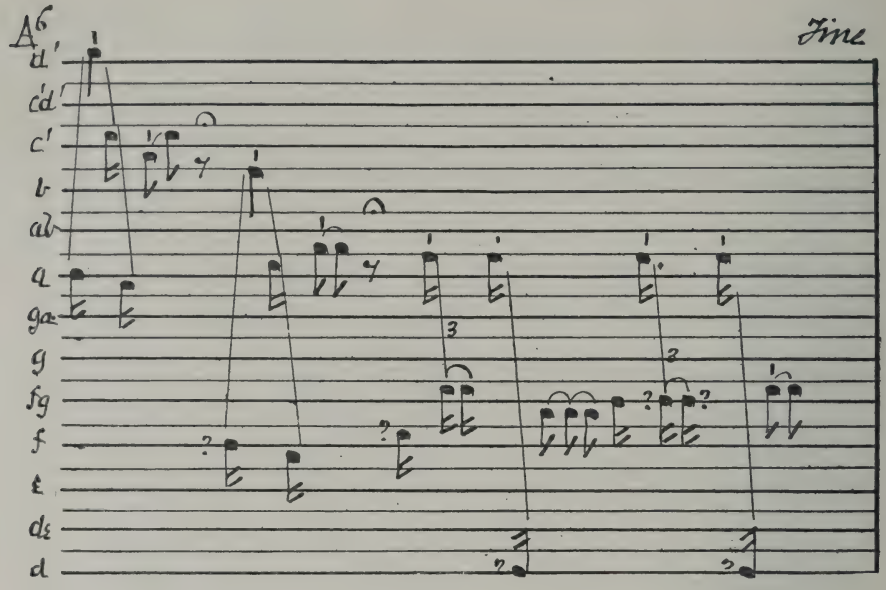



B'
165
A"
165
165

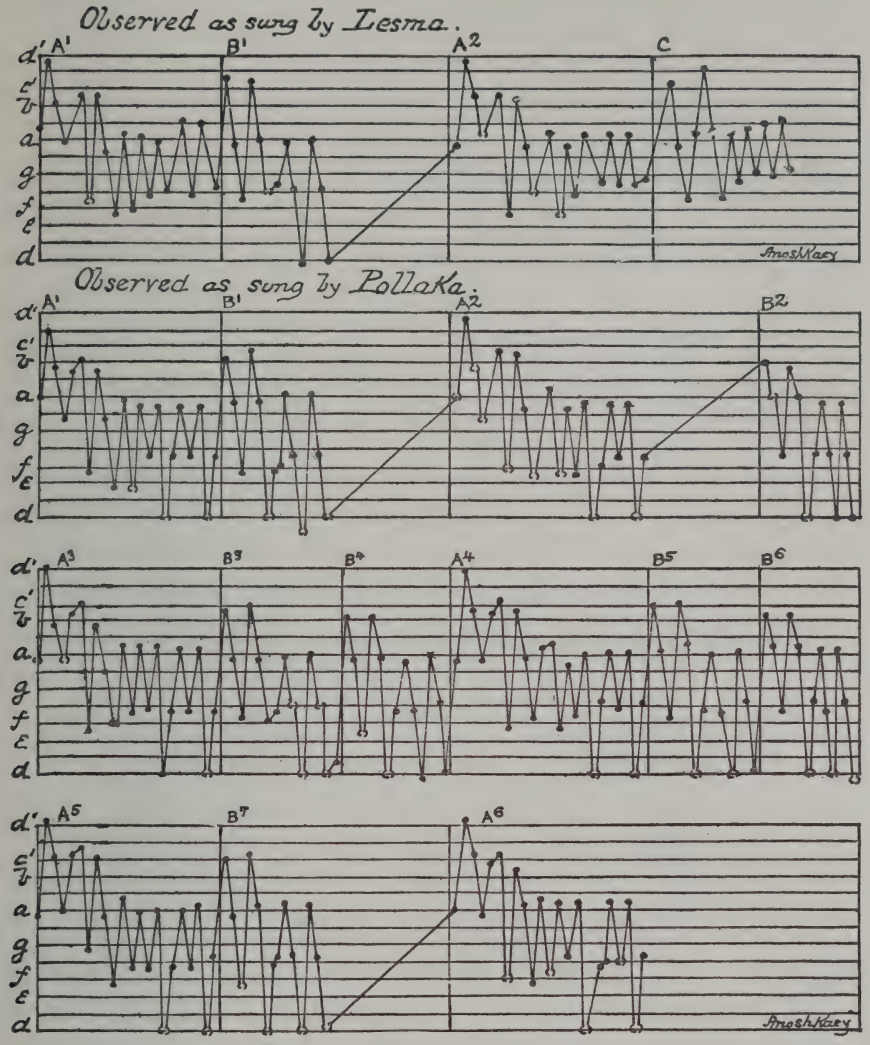

B2
A3
166
165
B3
165

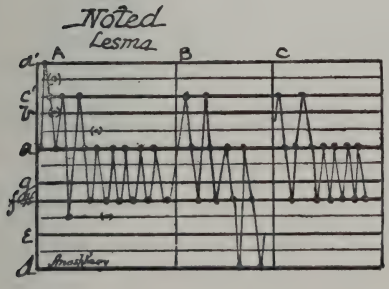

B4
A4
165
166
B5
166

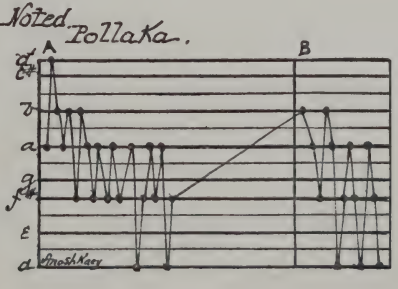

B6
A5
166
166
pp
B7
166-


Ab
Fine

COURSE OF TONE: ANOSHKAEY







ARGUMENT. (Polakka.) A trichord (d′–b–a; in A^2) is repeated, balanced on its base, as a major triad (c′–a–f; in A^4 and A^5), bearing a second (a–fg–d) pendent from the same note; and gives place to a third (c′–a–f), repeated pendent in like manner (a–fg–d) and reappearing as a trichord (b–a–fg; in B^2 and B^6).

WAYWARD and simple as this little melody seems at first sight, its performance by Polakka proves on closer examination to exhibit, like Shiashtasha, an elaborate rhythm of two slightly different readings of the two segments. The attention is first attracted by the recurrent narrow portamento (omitted in A^2) suggesting a symmetrical division of the opening salient fourth. This slide then proves to follow an initial division of the interval, approximating b in the three earlier A's and c in the three later; and finally to precede alternate choices of c and b as the upper limit of the movement in B, the lower limit tending to vary inversely.

Calling the A's major or minor as the opening salient trichord is major (a–c′–d′; the three later A's) or minor (ga)a–b–(c′d′)d′: the earlier A's) and the B's major or minor as the opening movement spans a fifth (c′–f B^1, B^3, B^5, B^7) or a fourth (b–fg: B^2, B^4(b–f), B^6); the rhythm executed by Polakka may be symbolized as follows:—

$$\underset{\text{Minor}}{A}\Big[\quad \underset{\text{Major}}{B} - \underset{\text{Minor}}{B} - \underset{\text{Major}}{B}\ ,\ \underset{\text{Minor}}{B}\Big]$$

$$\underset{\text{Major}}{A}\Big[\underset{\text{Major}}{B}\ ,\ \underset{\text{Minor}}{B} - \underset{\text{Major}}{B} - \Big(\underset{\text{Minor}}{B}\ ?\Big)\Big]$$

The course of the melody may thus be described: In A a movement in a salient trichord (a–b (or c′)–d′) becoming a tetrachord (a–b–c′–d′) is repeated a major third below, expanded to a major triad (f–a–c′: in A^5 beginning from g) tending likewise to become a tetrad (f–a–ab–c′); and followed by another occupying the fifth below the opening note. In B a third movement, alternately filling the field of the transition triad of A (f–a–c′) and retracted from both extremes to a trichord (fg (B^4f)–a–b), is repeated as a triad at the pitch of the final triad of A.

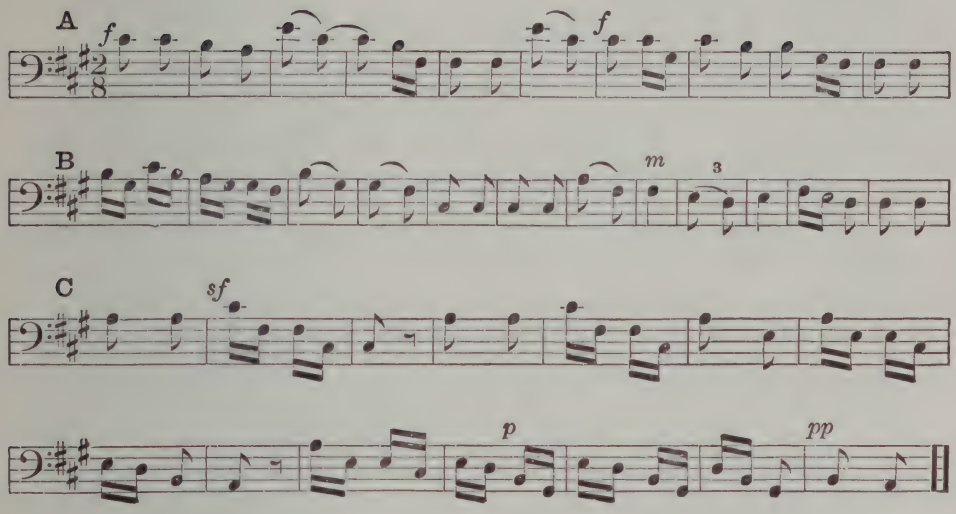
The song is throughout unusually irregular in intonation, the only pitch often reproduced being d, the lowest note. The opening note of

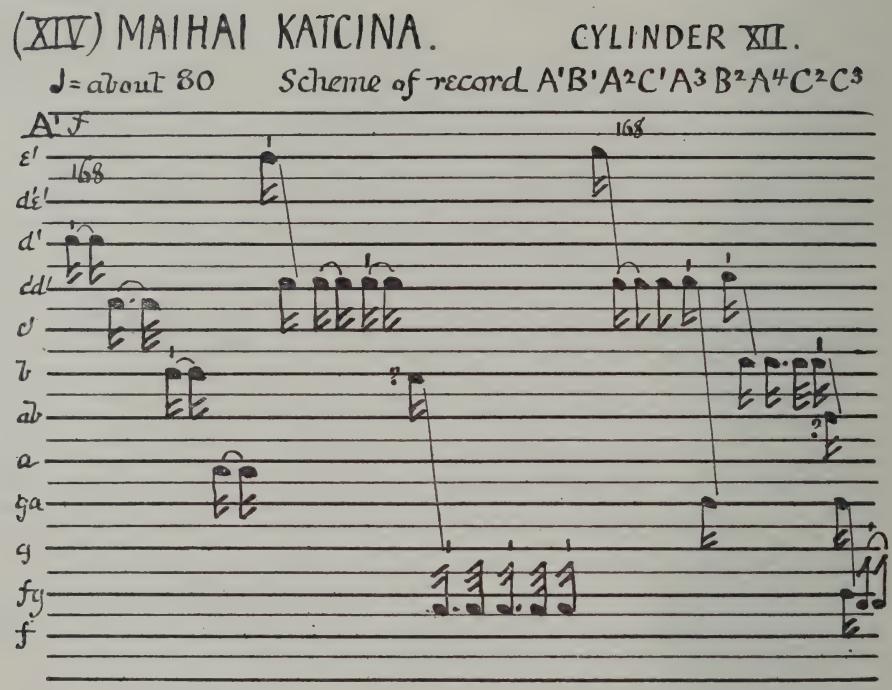
the first A has precisely the pitch of that of the last, but as in previous instances the singer takes time to find himself in the song. The division of the initial interval at b, a tone above the lower fifth, determines the segment as minor, most of the other notes and the opening of B being below the pitch of their later homologues. The distinction in the singer's mind between the two forms of B, major and minor, is reflected in the shift of pitch twice executed at the junction of the two movements in the major B's (B^1, B^3), but left out at the corresponding point in the minor B's (B^2, B^4, B^6). In the former a shift is necessary in passing from one major triad (f–a–c′) to the other (d–fg–a), but the fourth (fg–a–b) and the major triad (d–fg–a) of the minor B's fit accurately. The expressive content of the song is perhaps indicated in the whisper with which Polakka begins it, and in the sequence of the minor on the major B's like the fall of an echo. Even the wavering intonation may contribute to depict the flight of something ephemeral, or the destruction of something fragile.

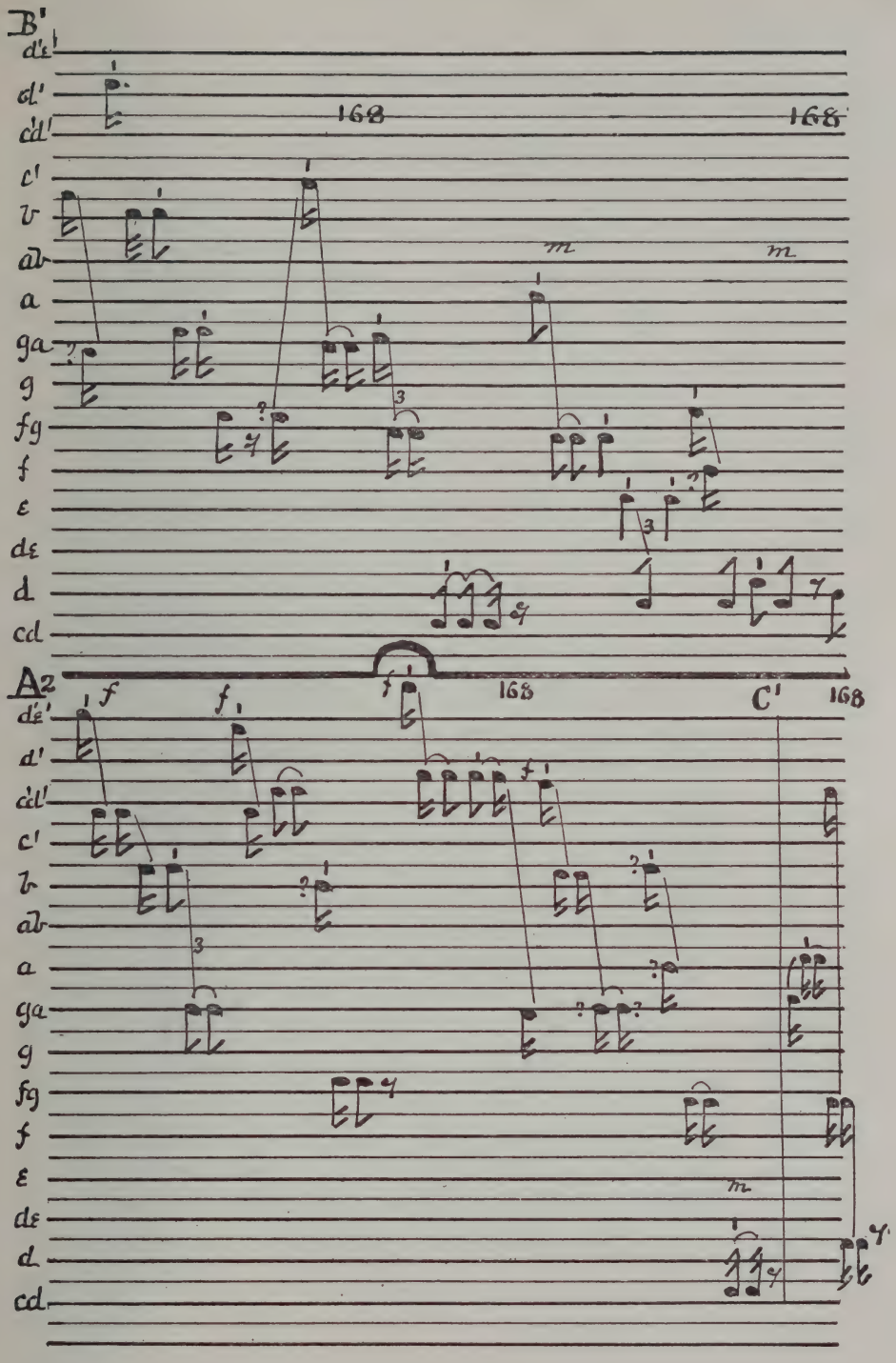
Lesma delivers the melody robustly and simply, not even troubling himself to finish his triads in A ; and makes short work of it, breaking away from the other version in C. His two A's reflect the types of Polakka's performance in the sequence in which they there appear, minor preceding major. His B is major and contains a suggestion of the shift in pitch made a feature of that reading by Polakka.

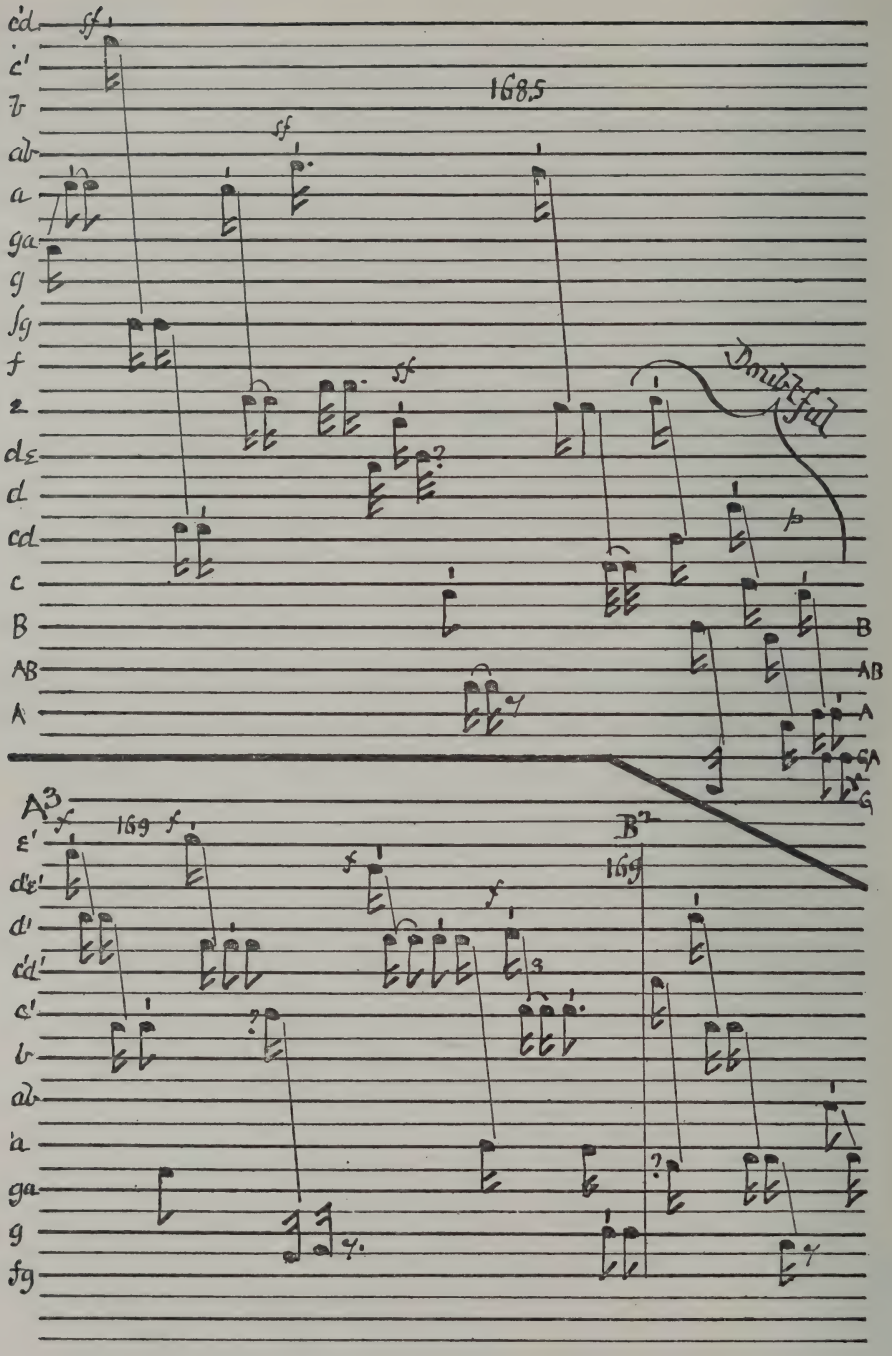
The staff notations confused the two renditions, giving B major to Lesma and B minor to Polakka, and noting various sporadic semitones only in Lesma's rendition. The chief structural feature of the melody, its combination of the major triads c′–a–f, and a–fg–d, the summit pitch of one being the interior pitch of the other, is adiatonic, and the fact is recorded in the f♮ of Lesma's notation. Elsewhere the staff notation gives a diatonic misrepresentation of the melody by reducing the transition triad to a tritonus (ascribed to Lesma) or fourth (ascribed to Polakka).

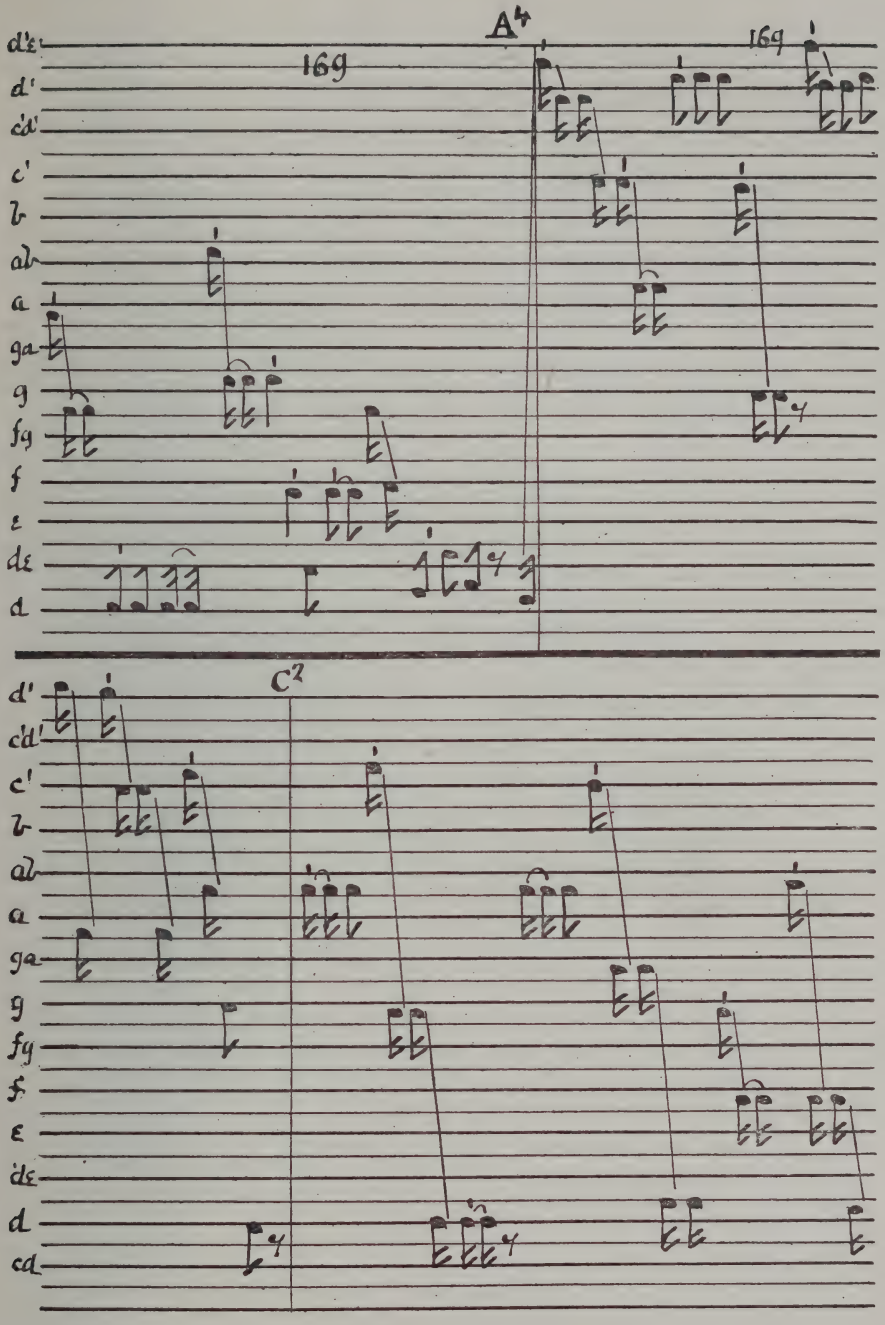
MAIHAI-KATCINA

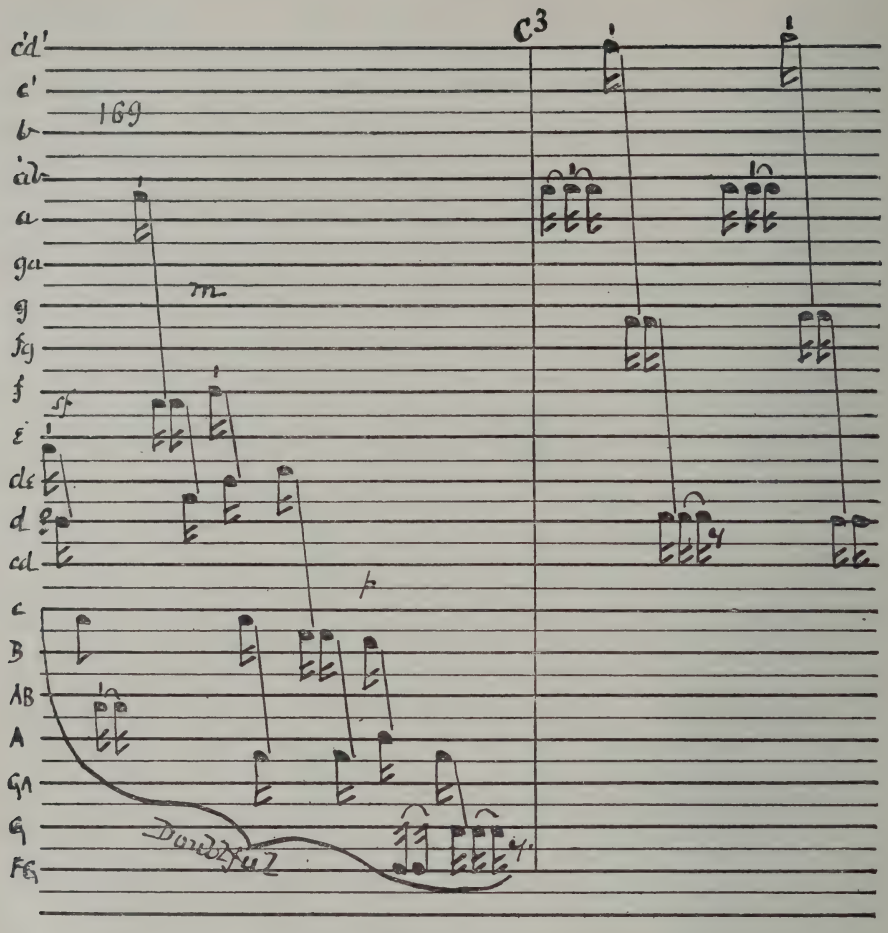


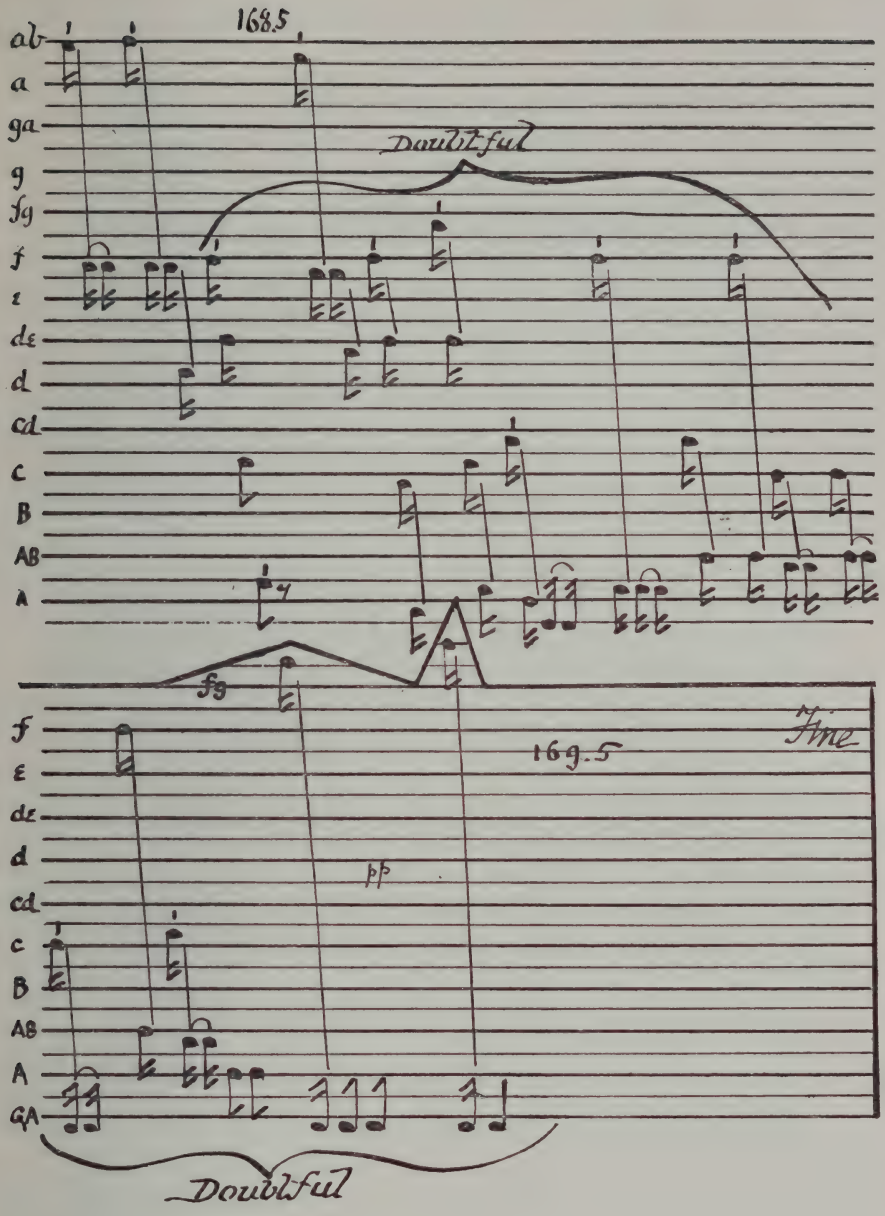

(XIV) MAIHAI KATCINA. CYLINDER XII.
♩= about 80 Scheme of record A'B'A²C'A³B²A⁴C²C³
A' f
168
168


B'
168
168
A2
168
C'
168

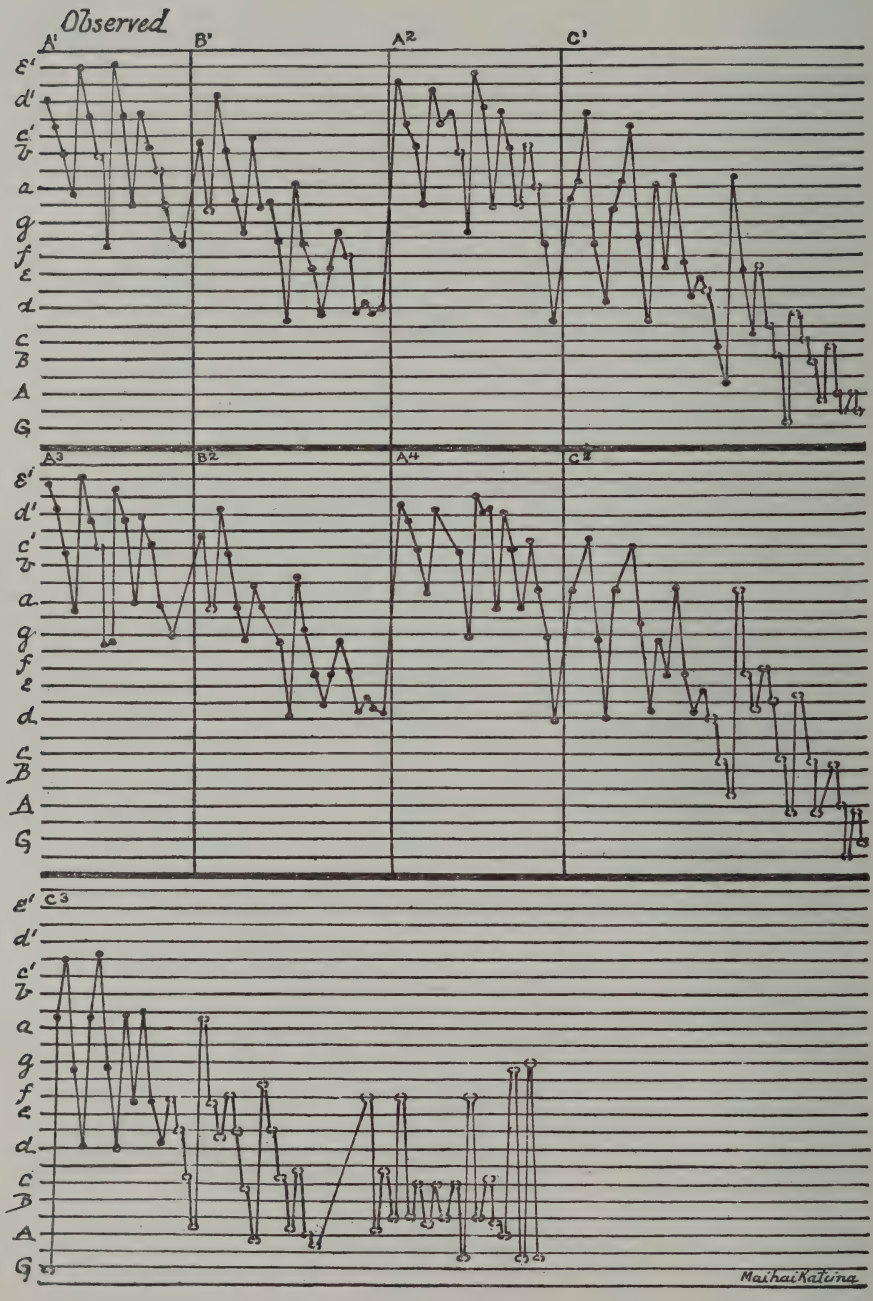

1685
Doubtful
A3
169
B2
169


A4
C2

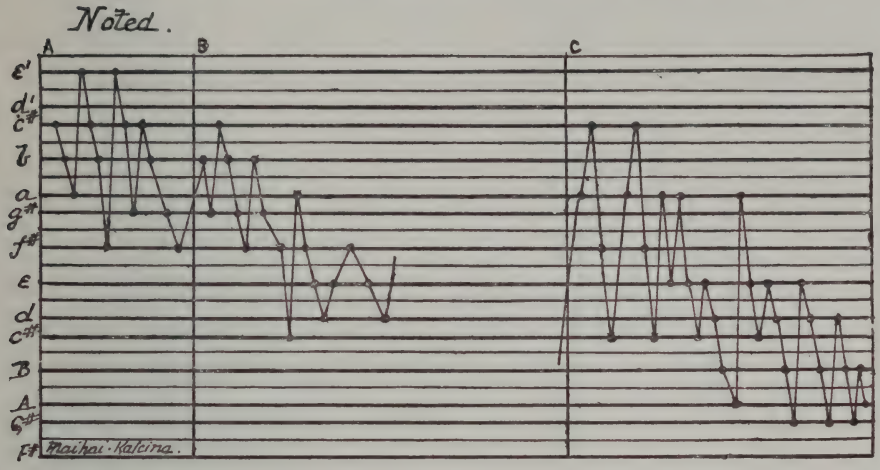

C3
169
sf
Dwindling


168.5
Doubtful
169.5
Fine
pp
Doubtful

COURSE OF TONE: MAIHAI-KATCINA



COURSE OF TONE: MAIHAI-KATCINA, CONCLUDED



ARGUMENT. A theme based on a tetrachord (d′–c′d′–b–a) is repeated after an interlude, the tetrachord expanded to a tetrad (d′e′–c′d′–b–ga); and after a finale the strophe is repeated, the tetrachord and tetrad changing places, the interlude contracted and the finale contracted at the opening, expanded at the close, and repeated, further expanded, with a coda.

GAY follows grave in this song as light chases shadow over a landscape. Like the preceding it presents an intricate rhythm of major and minor versions of its three segments, indicated unmistakably but by novel and subtle features.

The main movements of A^4 and the initial movement of A^1 are of less span than those of A^2 and A^3; the remaining wider movements of A^1 giving it the ambiguity noted before in initial segments. The second and third salient movements of B are both ampler in B^1 than in B^2; the final major thirds, fg–d in B^1, g–de in B^2, are divided higher in B^1, and the curious alternation of pitch at the close of B^1 before the leap to A^2, which is major, ends in a seventh tone rise, while the similar movement in B^2 before the leap to A^4, which is minor, ends in a seventh tone fall. Similar differences exist in the C's, differently combined for new reasons. The opening three movements of C^1 following A^2 (major) are wider than those of C^2 following A^4 (minor);

while the closing three movements of C^1 preceding the new strophe are narrower than those of C^2 preceding the close of the song. The singer's intent in both cases is obvious. The two strophes present an inverse rhythm of A's and B's: (1) A minor–B major–A major: (2) A major–B minor–A minor; and were the connecting C to remain major throughout, there would be no change of sentiment to mark the passage to the new strophe. The minor close of C^1 becomes the pivot on which the performer turns his fabric to show it again in the reverse colors. On the other hand, were C^2 to remain minor throughout, a contrast between the final repeated segments of the song would take the place of the more natural intensification of the one by the other. As the melody was delivered, C^3 enforces C^2's lesson of *good the final goal of ill*, by a major opening and a maximal close; running on into a pianissimo coda of fifths tending toward octaves that recalls the old-time major close of minor music.

The complete rhythm is the following:—

A^1	B^1	A^2	C^1	
Minor	Major	Major	Major-Minor	
A^3	B^2	A^4	C^2	C^3
Major	Minor	Minor	Minor-Major	Major-Maximal, Coda

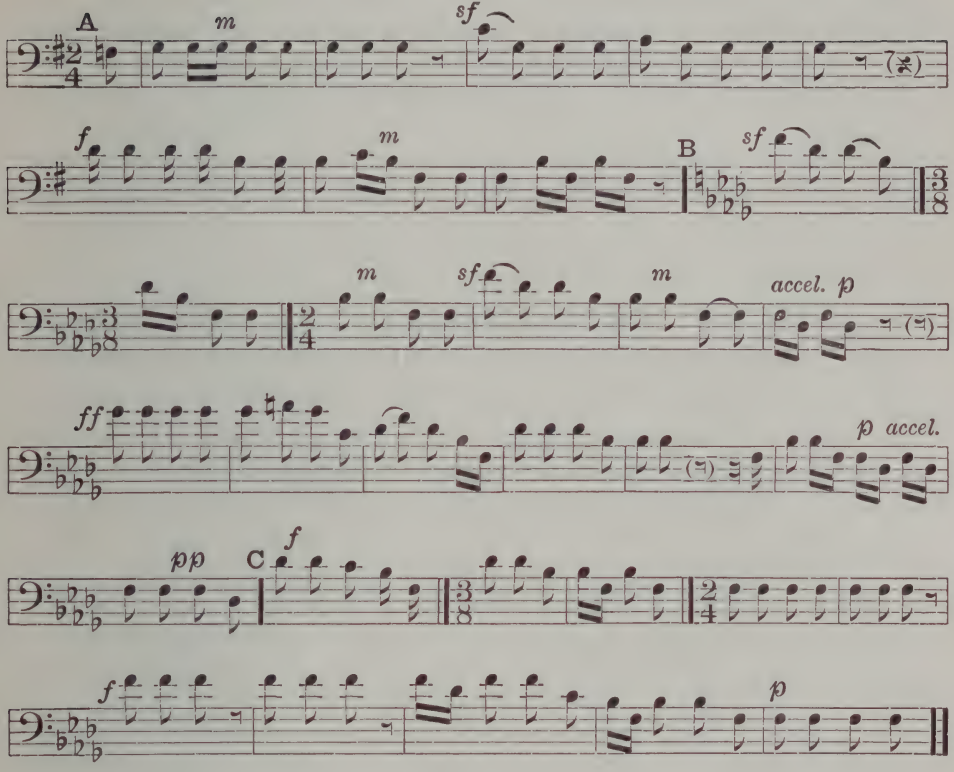
The movement of the major A's (A^2 and A^3) outlines a fifth extended downward a tone. In the minor A's the initial fifth becomes a fourth by the retraction of both the extremes and is extended a minor third. In the A's before the C's (A^2 and A^4) the movement is carried a fourth lower still. The base of the fifth is touched in the third and fourth movement, of all the A's, and the next semitone higher appears in the first movement of the minor A's (A^1, A^4) and the last movement of the A's before the C's (A^2, A^4). In the first strophe this base is pitched at ga; but in beginning the wide sweeps of C^1 the singer twice moves from about ga to about a, and the latter pitch becomes the base of the fifth in the second strophe.

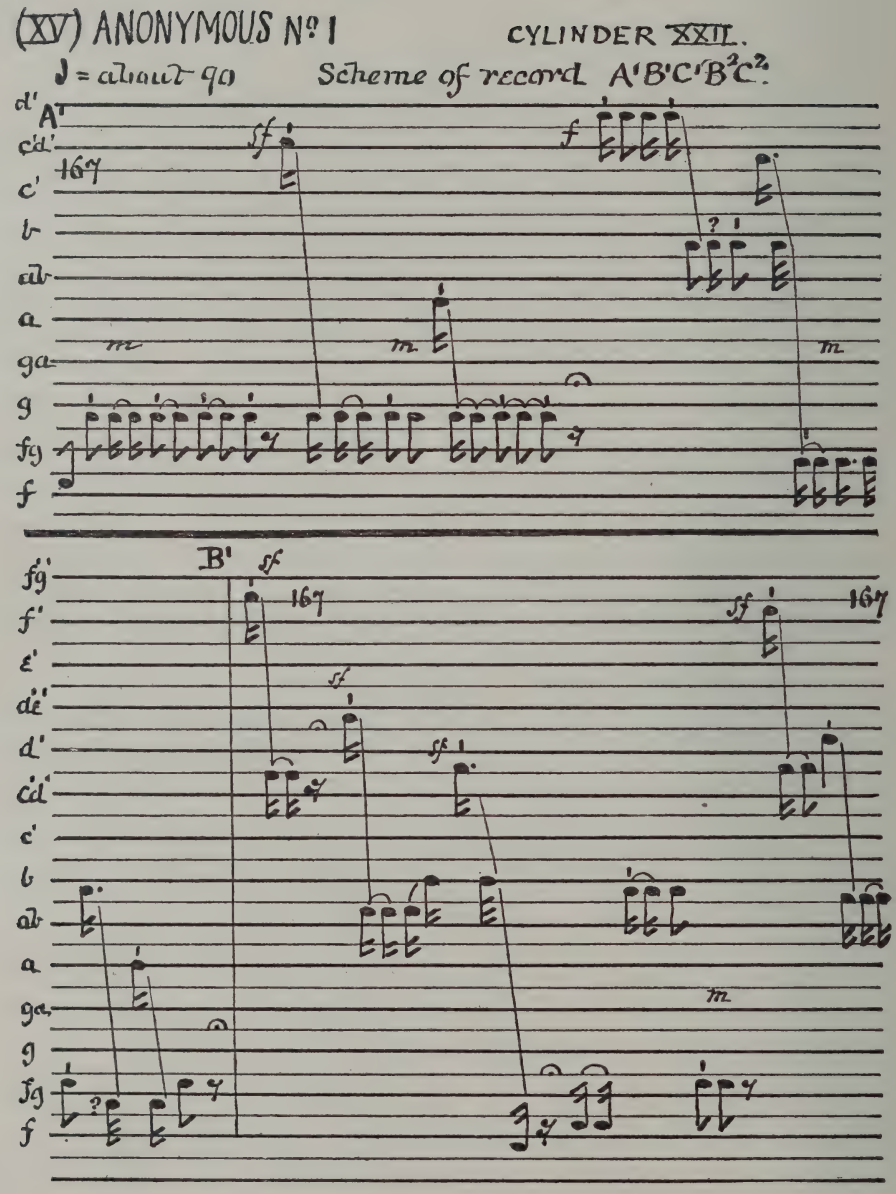
The staff notation contains no hint of the alternative forms which give this song its striking dramatic suggestiveness. The point of the double strophe was missed. The structure of the melody is not conspicuously

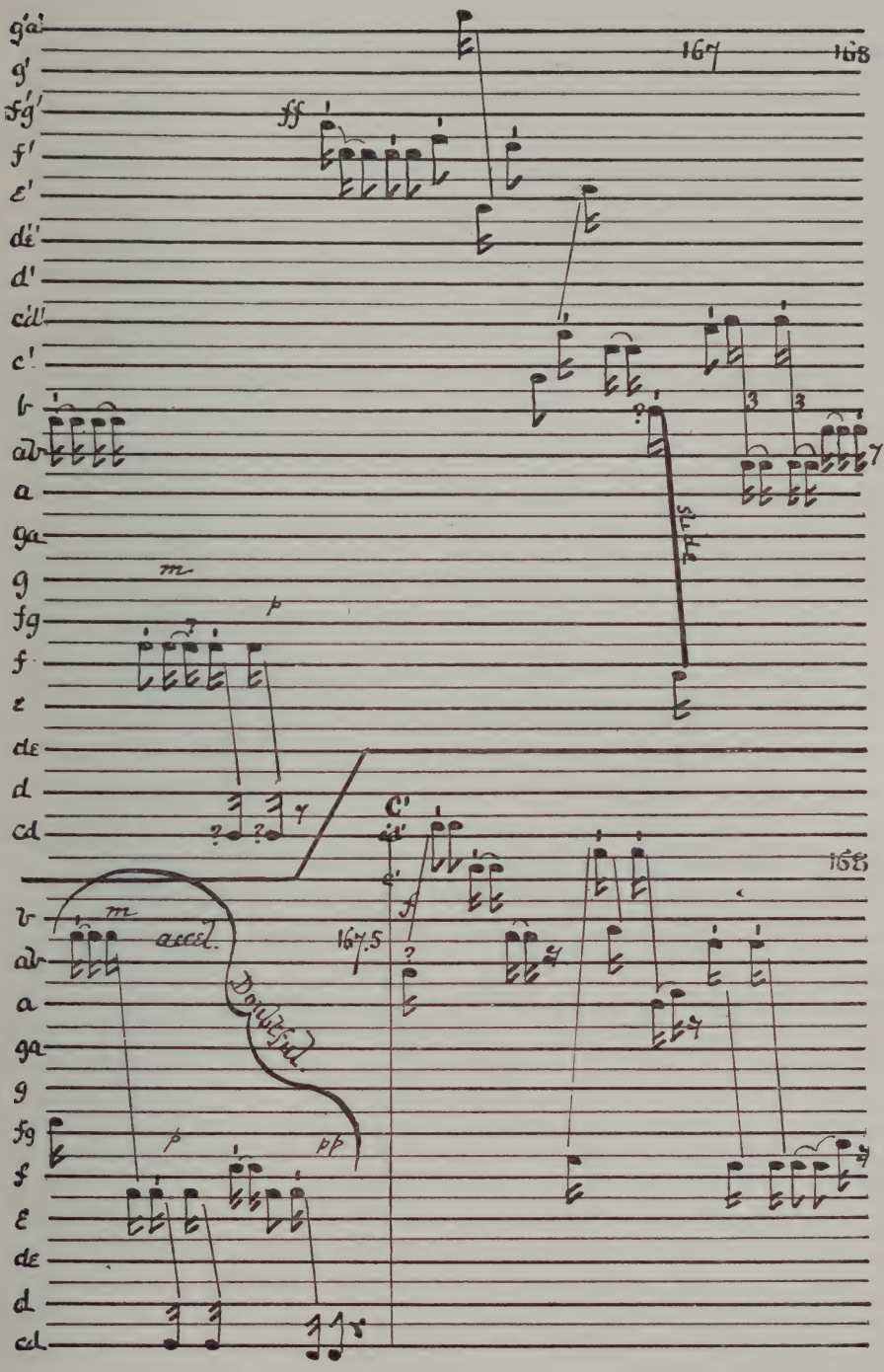
adiatonic, and a few alterations sufficed to bring it within the scale. The chief obstacle was the upper tone of A^2 and A^3, but from this the anomalous initial minor third of A^1 provided an escape.

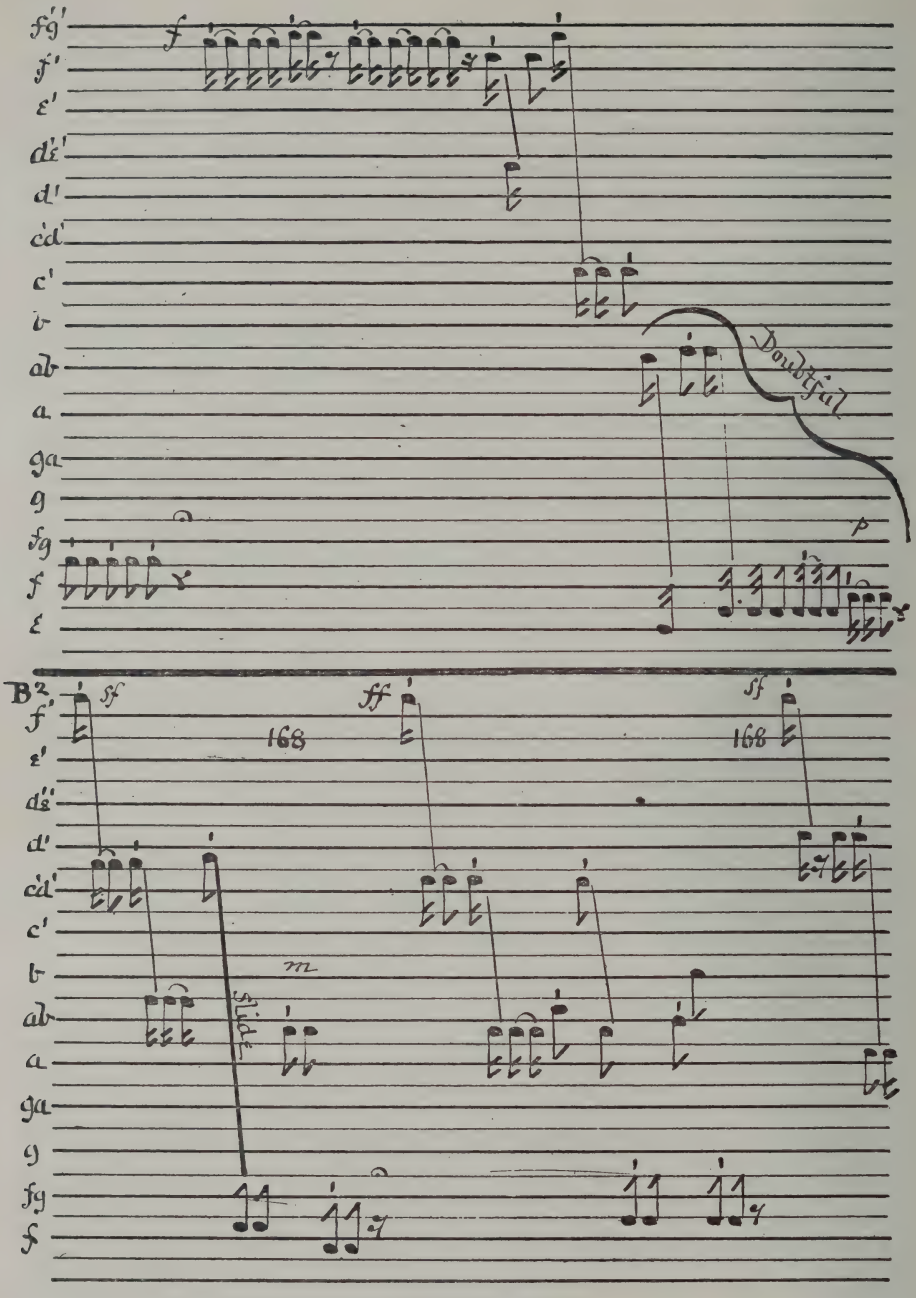
A comparison of C^2 and C^3, the two segments of the song which are most nearly simple repetitions one of the other, well illustrates a lesson of all this music. Up to the point in each where the judgments began to be doubtful, half of the intervals diverged in various ways at least $\frac{3}{14}$ tone from harmonic standards, yet the notes diverged the second time $\frac{1}{14}$ tone at most from their previous pitch in more than half the cases. In the interim the singer had executed a number of movements much lower in pitch. Harmonically his performance was a series of gross blunders; melodically it showed an exactness that makes want of will rather than want of skill the probable interpretation of its deficiencies. The inference is that this singer did not aim at intervals but at a melody. He did not try and fail to combine recognized standards of pitch distance into a sequence, but successfully followed a progression by pitch relations which had otherwise no precise existence in his mind. This progression was to him a familiar habit of fancy and voice, very exact in some features, structural and other, and approximate or variable elsewhere. It expressed his inclination toward the intervals of simple ratio directly and not through the choice of these or any others as standards.

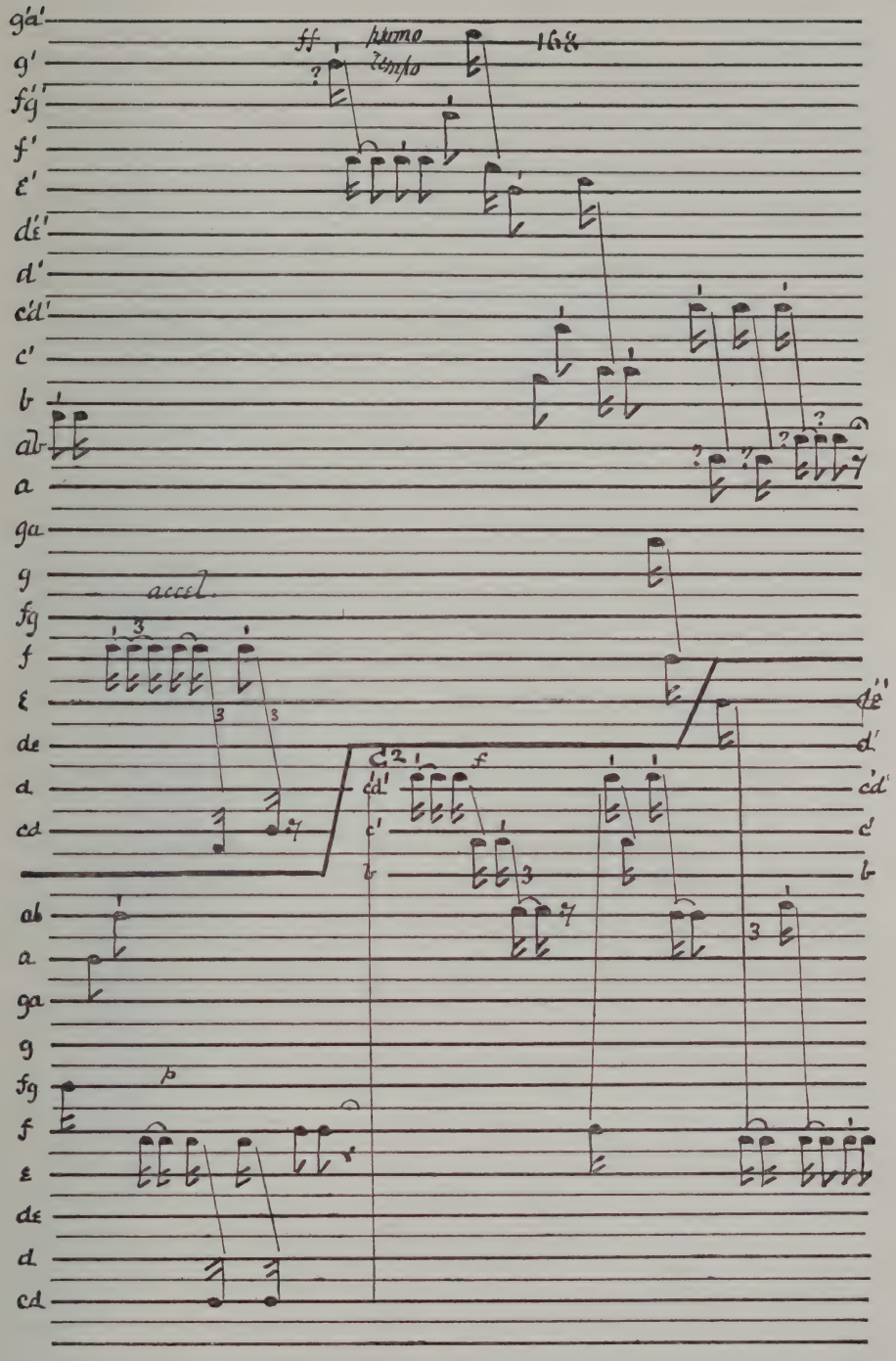
ANONYMOUS I

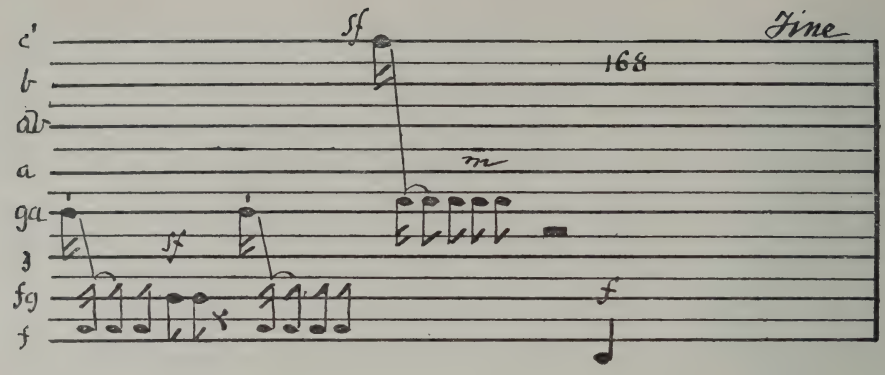



(XV) ANONYMOUS Nº 1
CYLINDER XXII.
♩ = about 90
Scheme of record A'B'C'B²C².
A'
B'
167

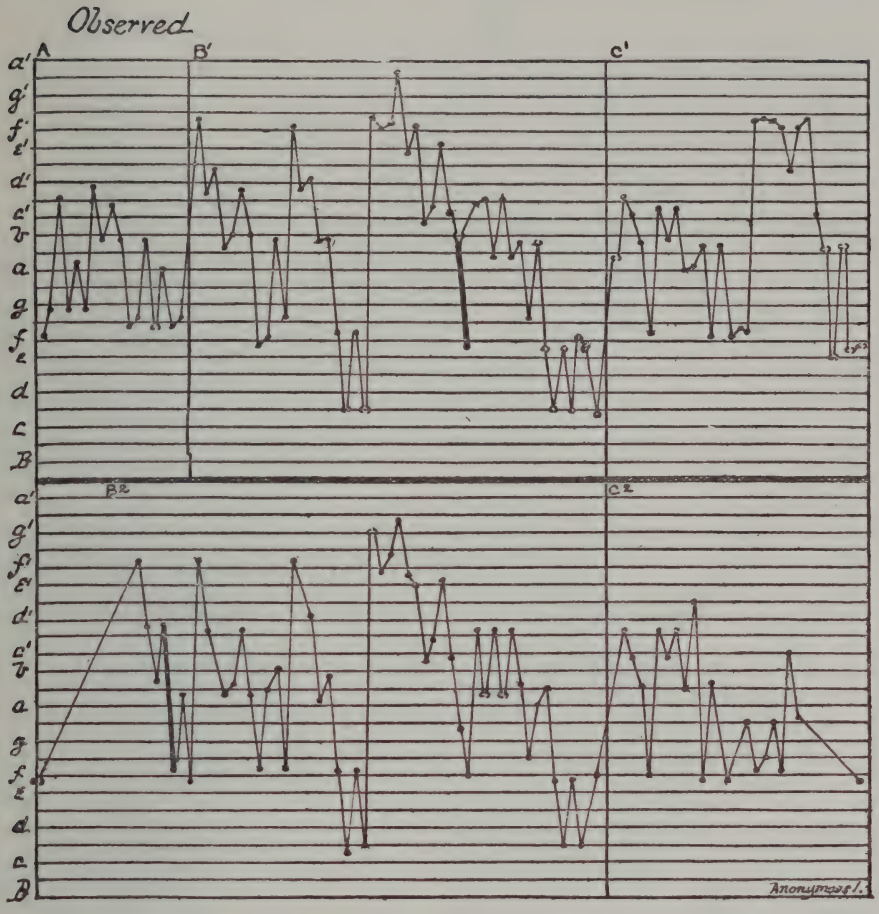

167
168
ff
m
p
accel.
Doubled
pp
C'
167.5
168


f
Doubtful
p
B2
sf
ff
sf
168
168
m
slide


ff
accel.
f
p

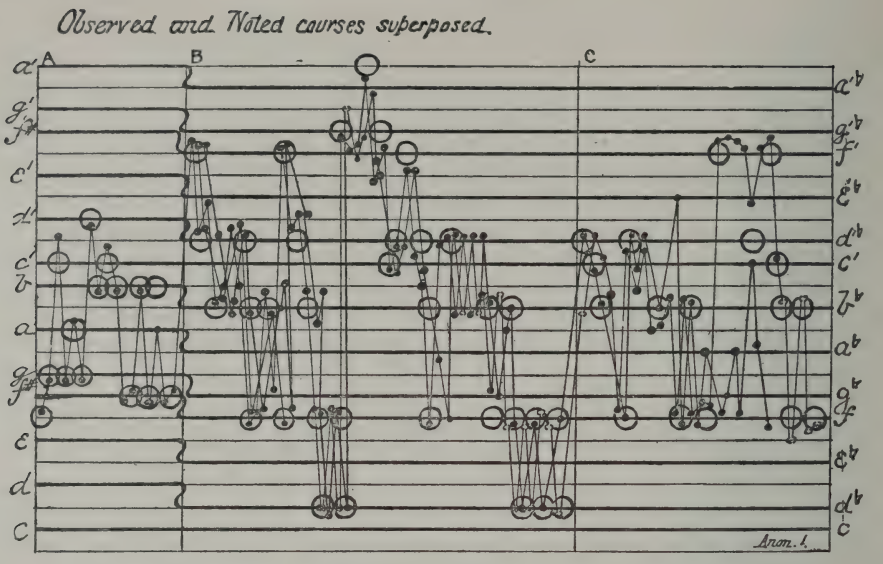

c'
b
ab
a
ga
g
fg
f
sf
sf
m
f
Fine
168

COURSE OF TONE: ANONYMOUS I

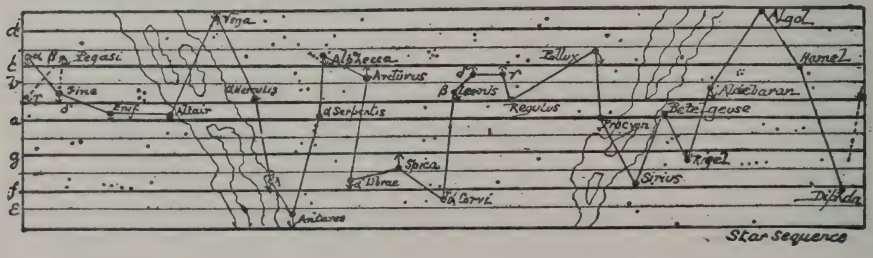


ARGUMENT. Thirds and fourths expand and contract in a chain (g′a′–f′–d′(c′d′)–b–fg(f)–cd).

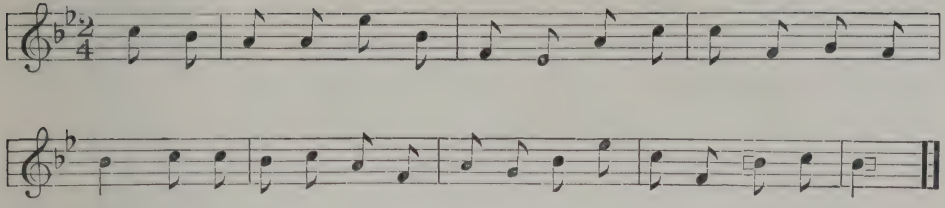
THIS song is unusually free in form; witness the extra initial movement in B^2, the different endings in C^1 and C^2, and many alternative intervals, the slides where the spirit moved, and the small movements of approach and return to notes with which the melody proceeds. The unaided ear was helpless to do otherwise than transform this variety into the humdrum diatonic sequences of the staff notation. Most of the semitones produced by the approaches and returns were neglected; that noted after the climax in B obtaining its undue prominence through its coin-

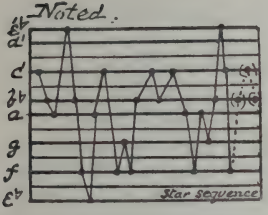


cidence with a semitone of the chosen key. The accompanying diagram superposing the observed and noted courses of the song shows that in eliminating the looseness of texture in which its specific musical character resides, recurrent notes at e′, d′, b, and a, approximately equidistant from two diatonic levels, were either referred to one of these or ignored. By this process any sequence of pitch or other variable may be recast as a diatonic air, and a less distortion will commonly suffice. The accompanying chart of the middle region of the northern heavens was traced from a small map, laid off into twelve equal spaces representing an octave of semitones and marked with a line connecting the brightest stars. The curve at once suggested a diatonic melody with a keynote at about 10° north declination, — γ and β Pegasi, which were not in the original choice, offering themselves for a tonic close. As in the Hopi song, so here a single step of the scale (d′ in the heavens, de



STAR SEQUENCE





in Anonymous I) is conspicuous by omission. Unworthy as this melody may be of the high repute of sphere music, the stars present it more correctly than does the Hopi singer the melody imputed to him. Their average aberration is less than $\frac{1}{5}$ tone, while the same number of notes at the beginning of his song average more than $\frac{1}{4}$ tone off the imputed pitch. The inference is that diatonic form is as little aimed at in the one case as in the other.

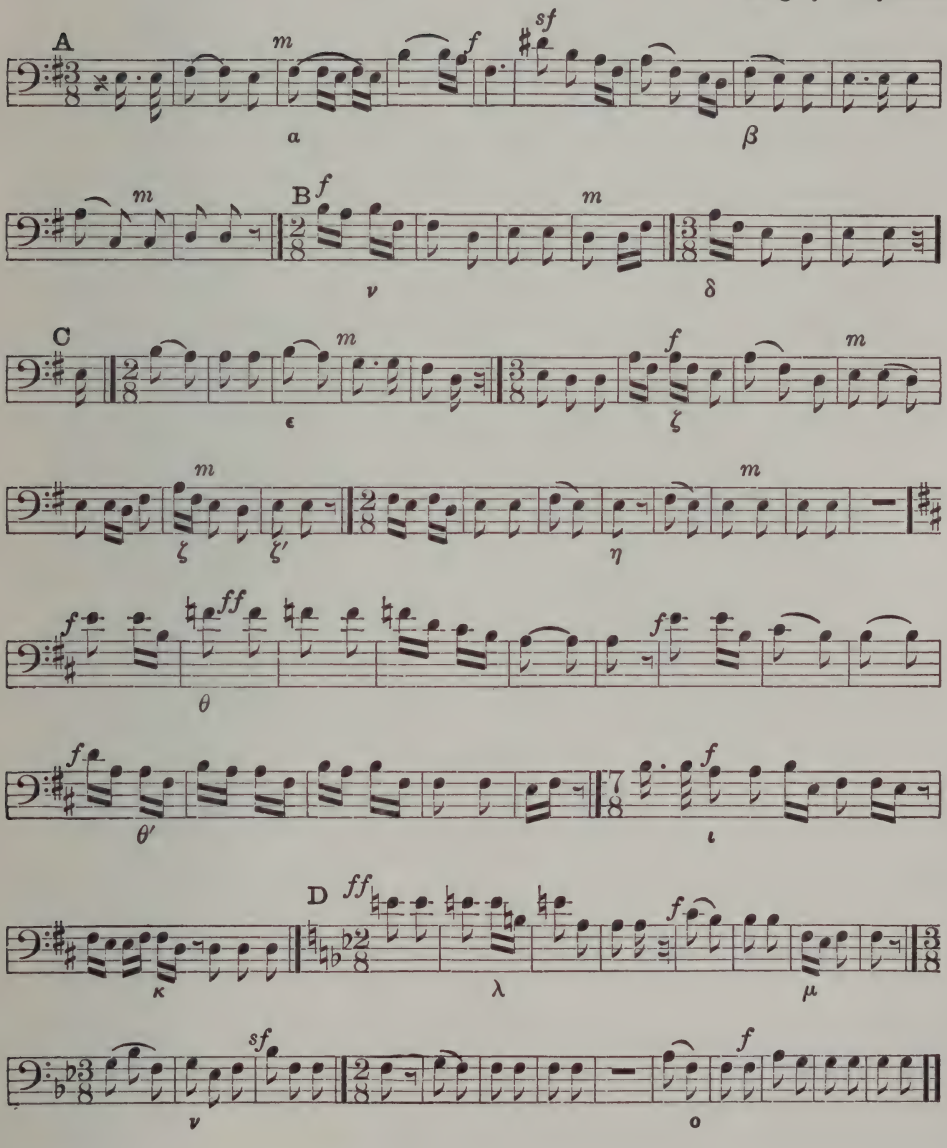
Apart from prepossessions of scale, the song appears a play of thirds and fourths expanding and contracting in all dimensions from a tone to a tritonus. In the opening movement of A the singer outlines the minor sixth, c′d′–f, in which the song centres; the second movement shifting this up a semitone and touching successively the fifth, c′d′, the fourth, b, and the minor third, a, within it. In beginning B^1 he rises a major third above this shifted sixth, descending to the base by lapped and withdrawn thirds and an augmented fourth; and by repeating these movements in less pronounced fashion regains the level of the opening movement within a $\frac{1}{14}$ tone at f+, emphasizing his permanent return to it by descending to the octave, cd, of its summit. In the climax which follows he completes the upper major third, f′–c′d′, to a fifth, with a crowning minor third, g′a′–f′, and descends lapping the first and withdrawing the second interval, sliding to f and returning through the initial sixth, c′d′–f, in its turn withdrawn to the fifth, c′d′–fg, and completed in a moment to the octave, cd. The opening movement of C^1 moves within the initial sixth, analyzing the upper third irregularly, and the closing movement forms an interlude between the strophes,

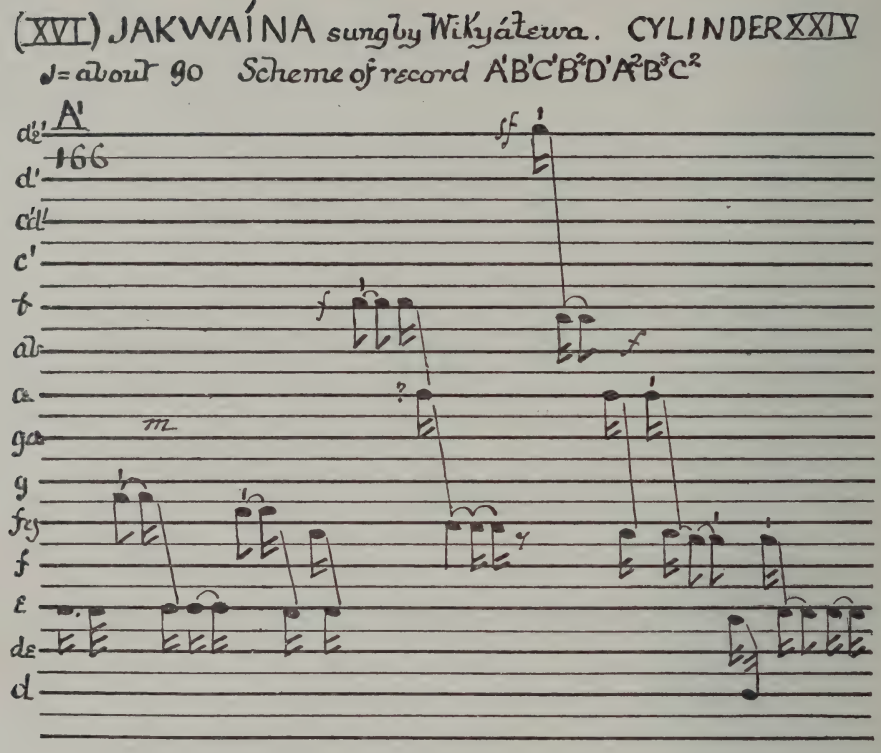
retracing the boundaries of the song within its two outlying intervals. It opens the second strophe upon f− instead of f+, the note having already touched the lower level at the end of B^1, and continuing to oscillate between the two to the end of the song, where it drops a $\frac{1}{14}$ tone further. Notwithstanding this difference of about a $\frac{3}{4}$ tone in the start of B^1 and B^2 (fg+and f−), the homologous notes in the first movements of the two are almost precisely the same in pitch, and in the movements before the climax the central notes are identical. In the descent from the climax the notes of the approximate semitone f′–e′ take the inverse order of their homologues in B^1, suggesting a trick of memory like that which has brought the English "through" out of the Anglo-Saxon "thurh." A similar inversion, and perhaps of like origin, occurs at the end of θ^1 in the next song. In C^2 the singer finally dismounts the initial sixth piece by piece, as he had built it up, at a semitone higher level, in A.

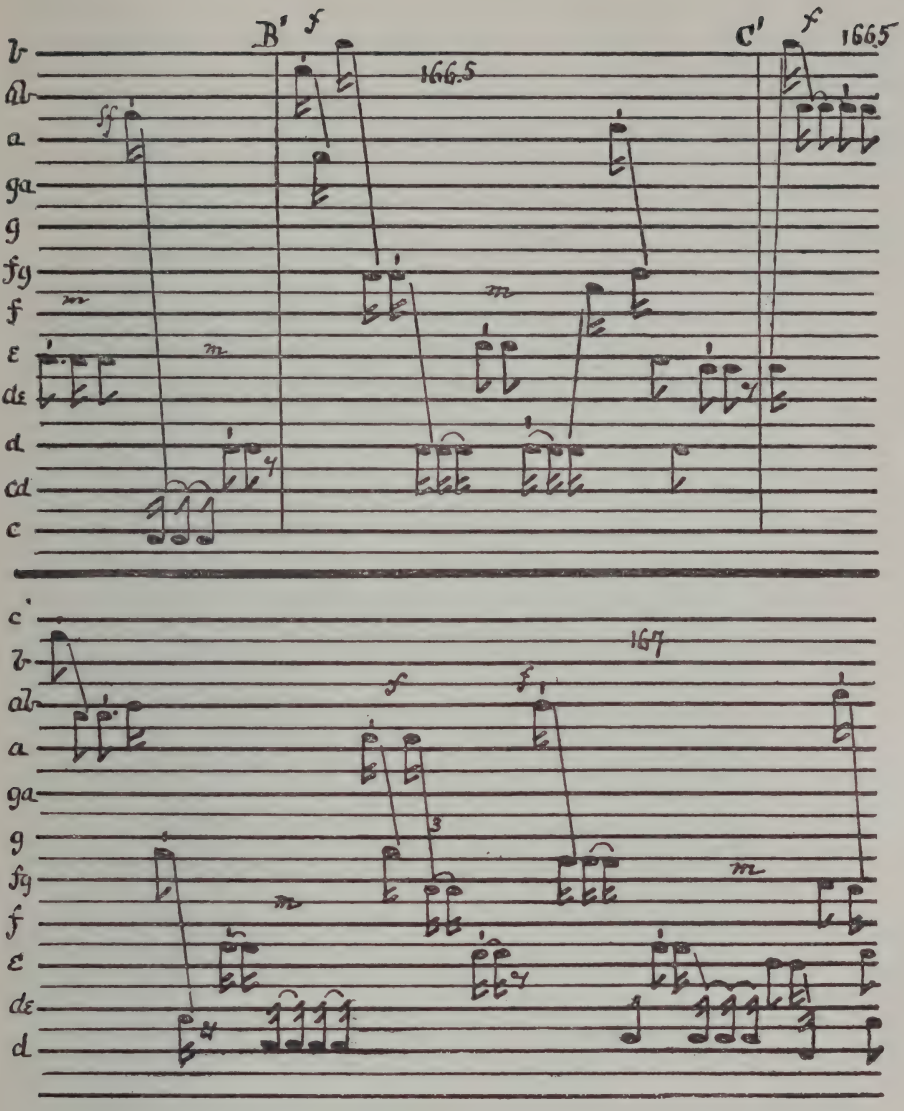
Vagrant as this melody seems, the identical pitches attained in the course of the B's and in opening the C's give proof of no little virtuosity. To repeat without accompaniment a complicated chromatic sequence — for instance, the second part of the Pilgrims' Chorus in "Tannhaeuser" — and give any of the notes at all just the pitch of their first performance is a commendable feat for a European singer. Its accomplishment by this Pueblo musician with his hyperchromatic melody evidences the power of habit when undisturbed by a scale-consciousness; but it also implies great delicacy of auditory and muscular endowment. Such refinement of execution by an artist of an unhistoric race is in no way unexampled. The early vestiges of civilization are full of evidences of acuteness of sense and command of muscle rarely paralleled in later times.

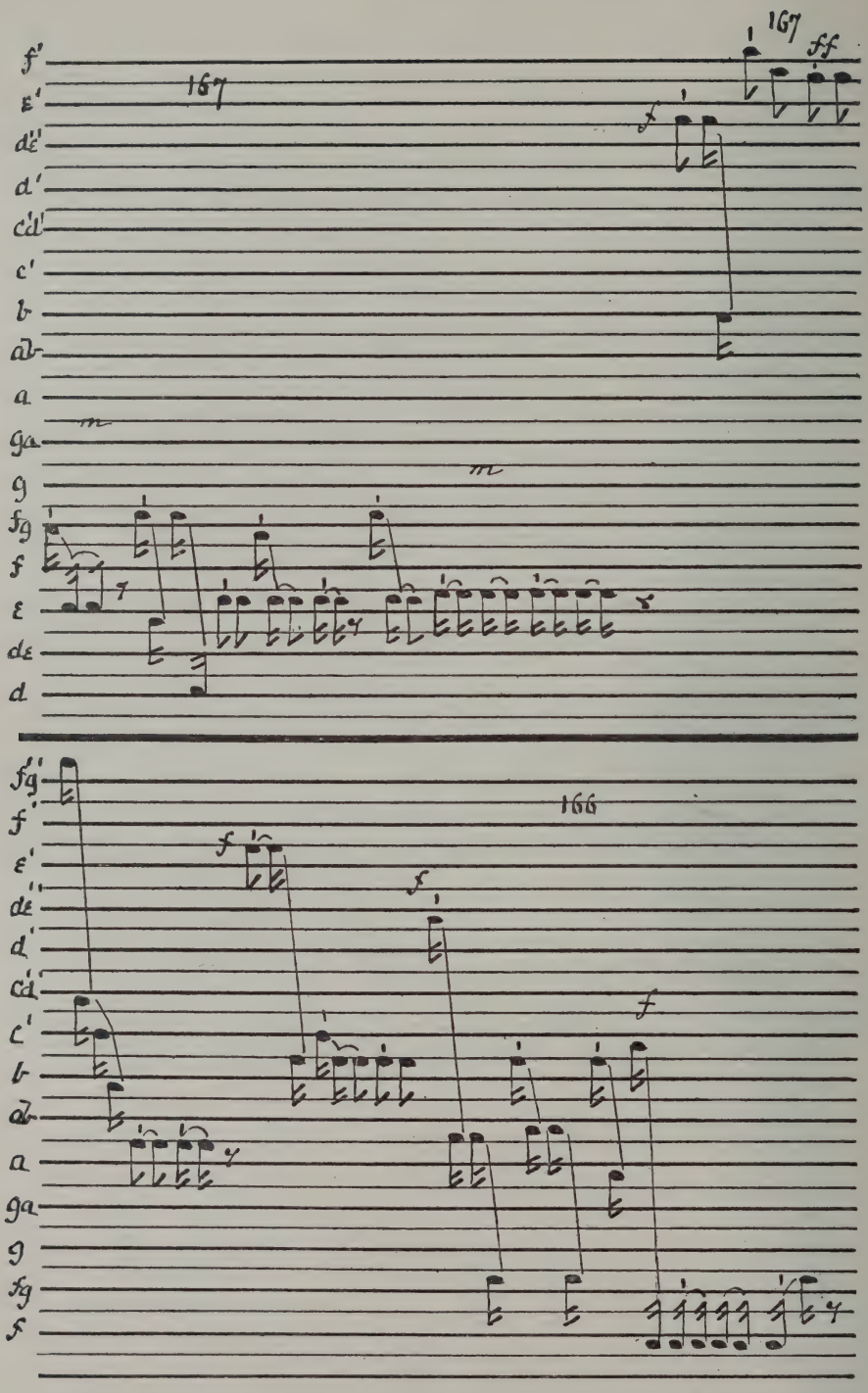
JAKWAINA

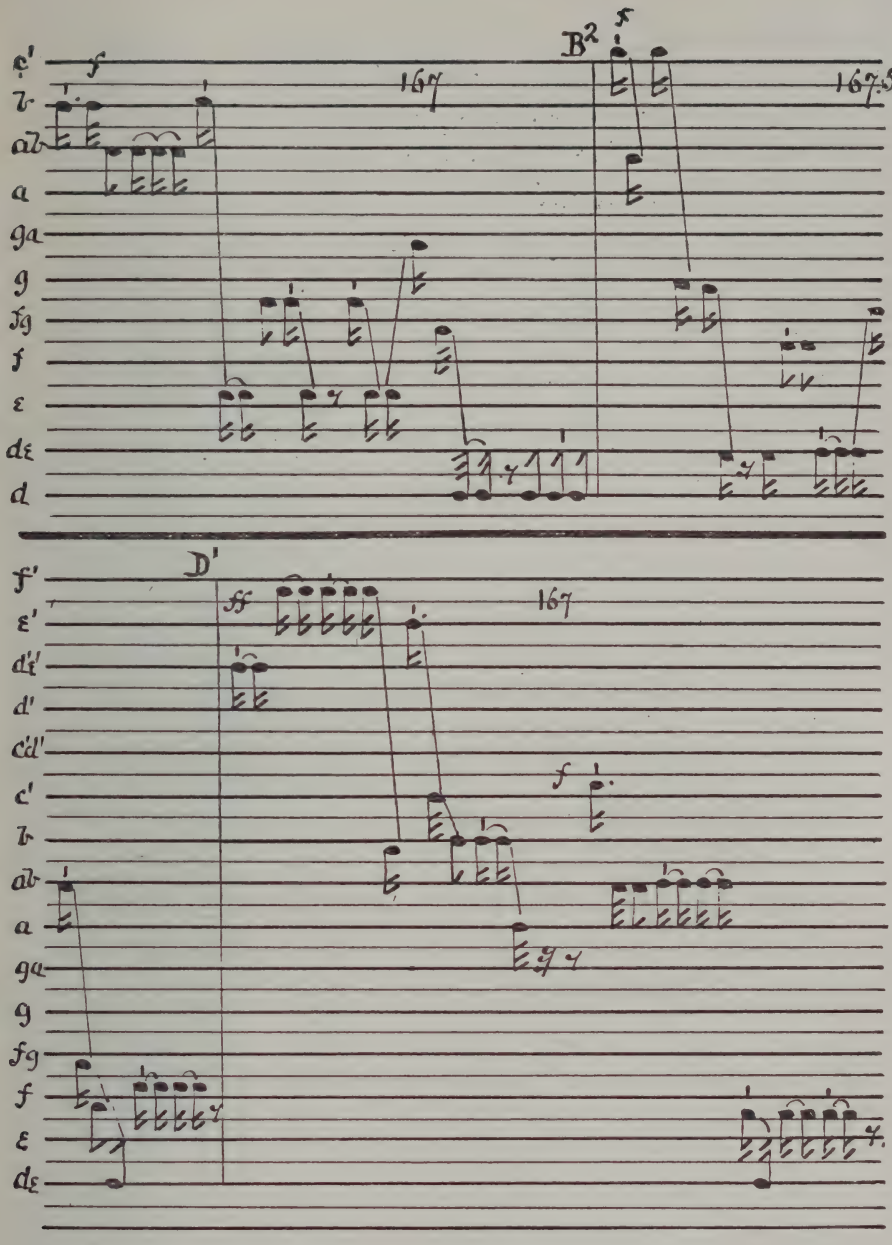
Sung by Wikyátewa

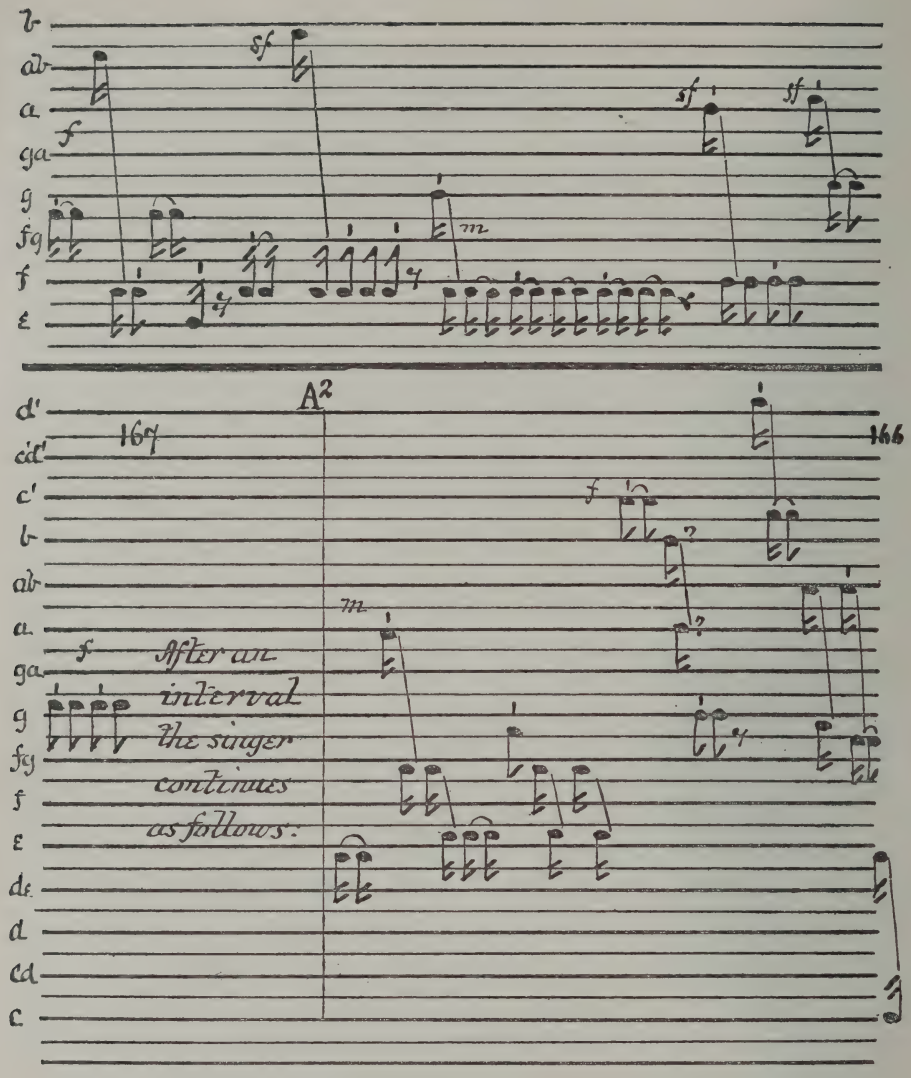


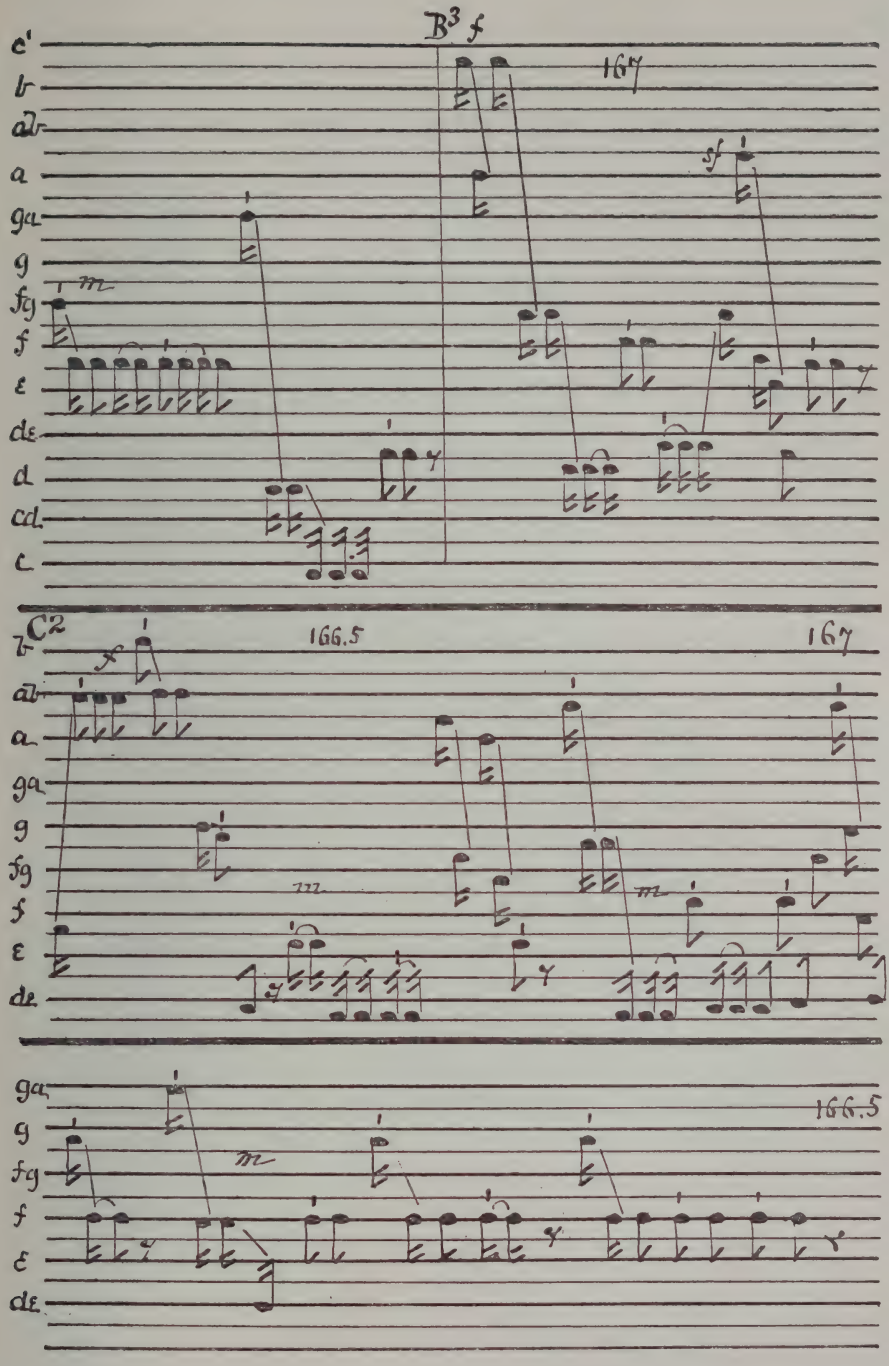

(XVI) JAKWAÍNA sung by Wikyátewa. CYLINDER XXIV
♩= about 90 Scheme of record A¹B¹C¹B²D¹A²B³C²
A¹
166
sf
f
m

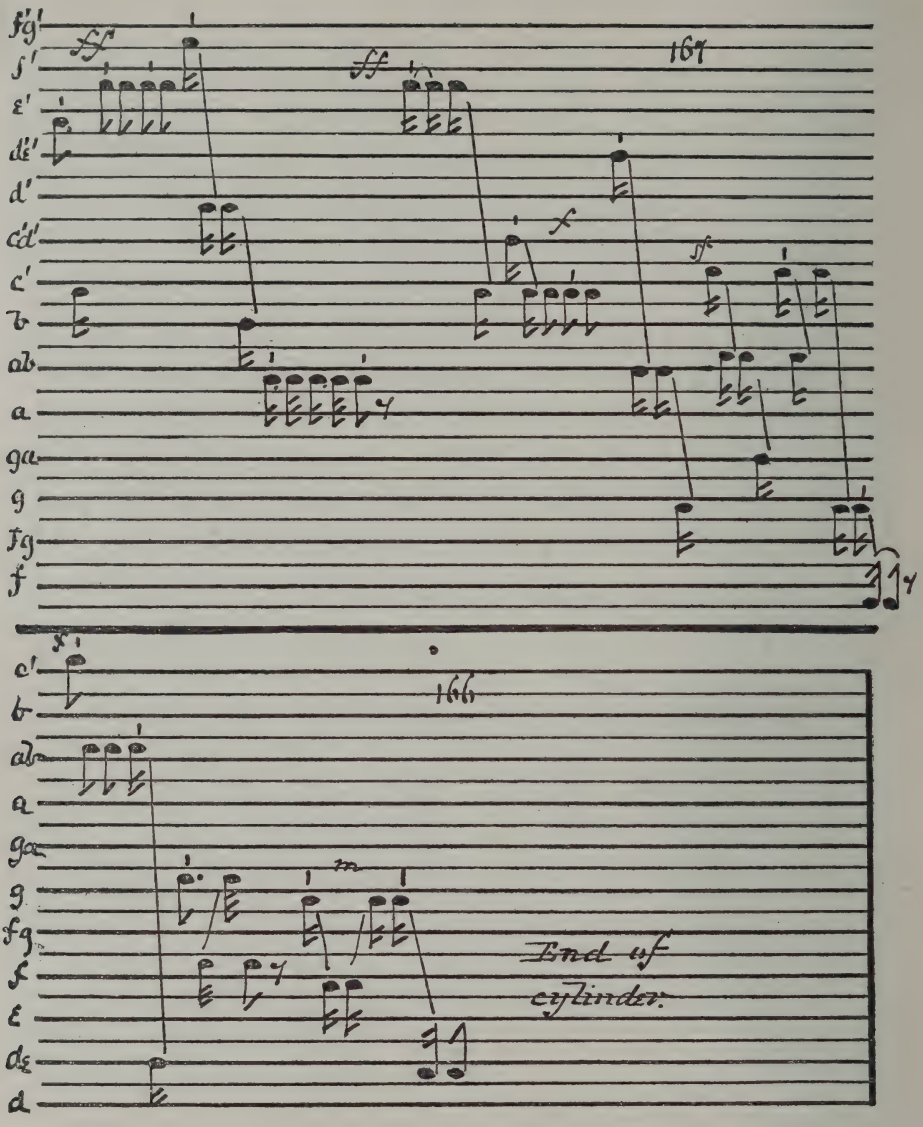

B'
C'
1665
1665
167


167
167
ff
166

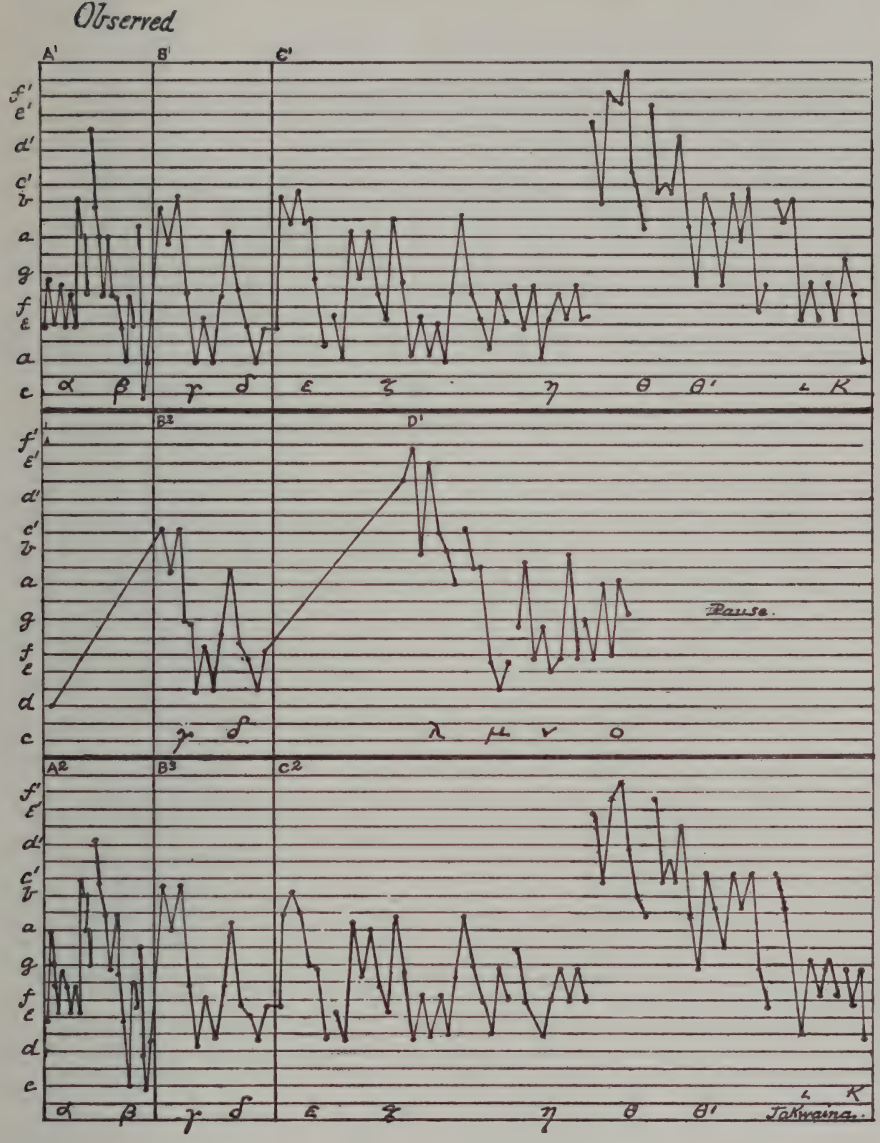

B2
5
167
167.5
D'
167


A2
After an interval the singer continues as follows:

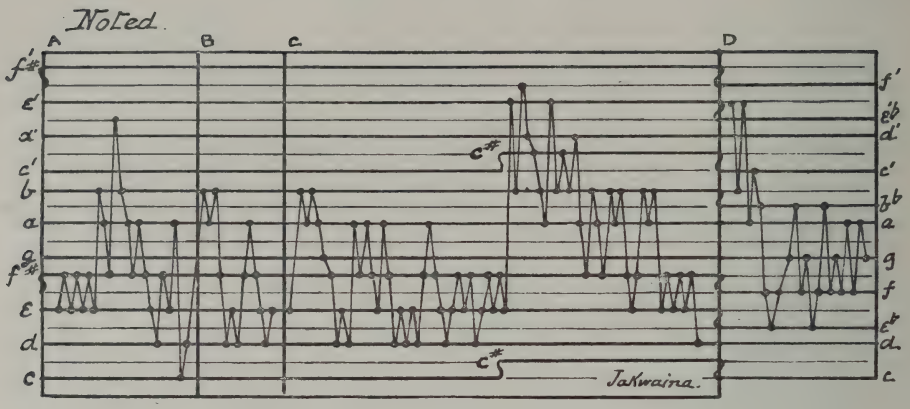

B3 f
167
sf
C2
166.5
167
166.5


167
166
End of cylinder.

COURSE OF TONE: JAKWAINA



COURSE OF TONE: JAKWAINA

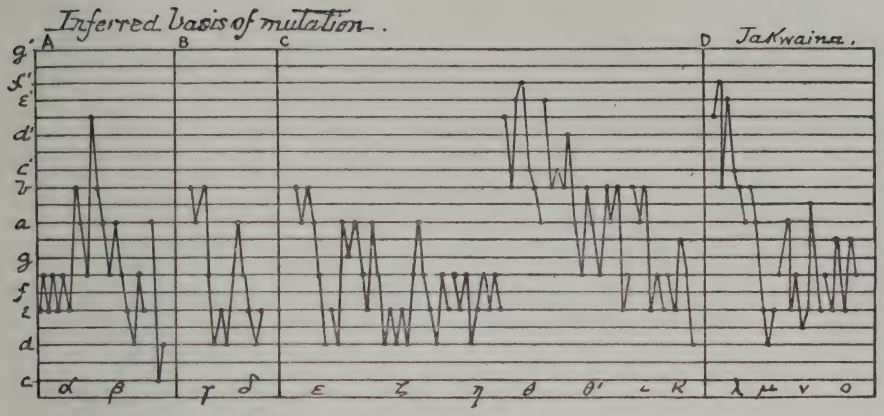


ARGUMENT. A tetrad (a–fg–e–d) augmenting upward intermittently (ϵ, triads of ζ), another superposed (e′–c′–b–a : with other mediants) first rises with it (C^1 ; θ, θ', ι) and then reacts (D^1; λ) and upon the tetrad beneath contracting upward (C^2, ϵ, ζ) rises correspondingly, permitting it to regain its figure (C^2, θ–κ ; ab–g–f–de).

A FANTASIA-LIKE sequence of contrasted motives repeated after the rehearsal of one segment, B, with an interlude, D, and shaped and finally shifted upward a semitone in the process.

The shaping and shifting may be followed with the aid of the diagram of their inferred basis. The field may be described as a doubly divided fourth, a–g–fg–e, extended to a major sixth, b–d, by tones, b–a and e–d, above and below, the lower developing into the major third, e–d–c, the upper capped by the major third, d′e′–b, and eventually developing into the fifth, e′–a, and minor sixth, f′–a.

The movements in A^1, α and β, are chiefly confined to the sixth, b–d, the final three notes breaking abruptly into its swaying movement (to our ears with very much the air of "Nicht diese Töne!") and introducing the lively motives of B, γ and δ, observing the same limits. C^1 is divided into two sections, an interlude, η, rehearsing the three lower notes, fg–e–d, of the initial sixth, b–d, following two themes, ϵ (slow double time) and ζ (quick triple time), and introducing three others, θ in the crowning major sixth, f′–a, θ' in the fifth e′–a prolonged

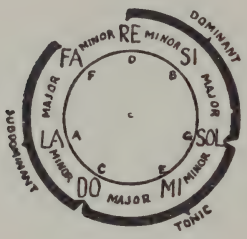


in a rapid downward close, and ι, a short phrase in changed time. Another interlude, also rehearsing fg–c–d and adding ga, introduces B². During C¹ the outlines of the melody, constant through A and B, begin to ascend intermittently, in ϵ, the triads of ζ, and the summit of θ with its developments in θ′ and ι, the intermediate movements adhering to the old level. The summit, a, of the initial fourth can be seen on its upward way from θ to ι. In B² the semitone shift upward to the new sixth, c′–de, takes place decisively, although one note, the axial fg of δ, clings to its original pitch. D¹ reverts in λ to the initial level, executing the crowning sixth on the pitches f′–e′–d′e′–c′–b–a, but forthwith ascends again to the level of B² in two themes, μ and ν, the second in triple time, the coda o ending on the new central note g. The ensuing pause marks the end of one performance as in Shiashtasha, A² recommencing a fourteenth tone below the opening pitch of A¹. At once the singer combines upper notes, d′, c′, ab, of the new sixth with the lower notes, a, fg, e, d, and c, of the old one; then, ending β on de– instead of on the initial d–, he shapes B³ and the first part of C² in the opposite way by raising lower notes and holding upper ones, reducing the span of this stage of the song by an approximate semitone. The shift finally becomes complete in the fortissimo of the close of C².

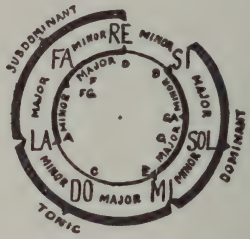
The living prehensility and contractility of this music appear at a new angle in the figure of this song. Afflatus or caprice raises the triad of ϵ in C¹ a semitone above that of δ and broadens the main field of the

movement from a fifth to a minor sixth. Thenceforward the boundaries of the melody are ductile and compressible within these double outlines.

The combination of intervals shown in the diagram of the inferred basis of mutation is in the main diatonic and is approximately expressed in the staff notation. The exceptional progressions are explained by the context of the melody and confirm the inference that this and not any independent system of harmonic relations determines its course. The European musical consciousness consists essentially in the grasp of the complex of triads shown in the accompanying diagrams of the major and minor modes of the diatonic scale. The two adjacent semitones of θ, in-



MAJOR MODE.



MINOR MODE.

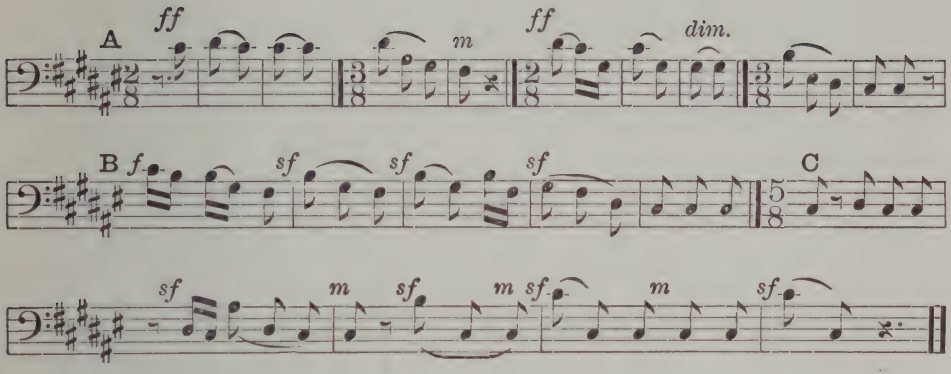
ferred as d′e′–e′–f′, and of μ and ν, d–de–e, appear in the diagram of the minor mode as any two of the series E–A (used in Gounod's "King of Thule"), but in each case a third either below or above is minor in the scale instead of major as in Jakwaina. The minor mode provides also three minor thirds in sequence, GA–B–D–F, but not the four exemplified by the summit and foot of κ with the two previous inferred summits: d (double minor third), ga (minor third), b (minor third), d′. These progressions accord with the habitudes of the singers. The major third, d′e′–b (inferred), of θ is an approach to, and f is a flourish beyond, the crowning fourth, e′–b. In μ the inferred fifth, b–e, is momentarily extended to a major sixth by d, in ν the fourth, a–e, to a tritonus by de. The ga of κ makes a major triad of the fifth just executed, and the note is repeated in o, similarly dividing the fifth of μ.

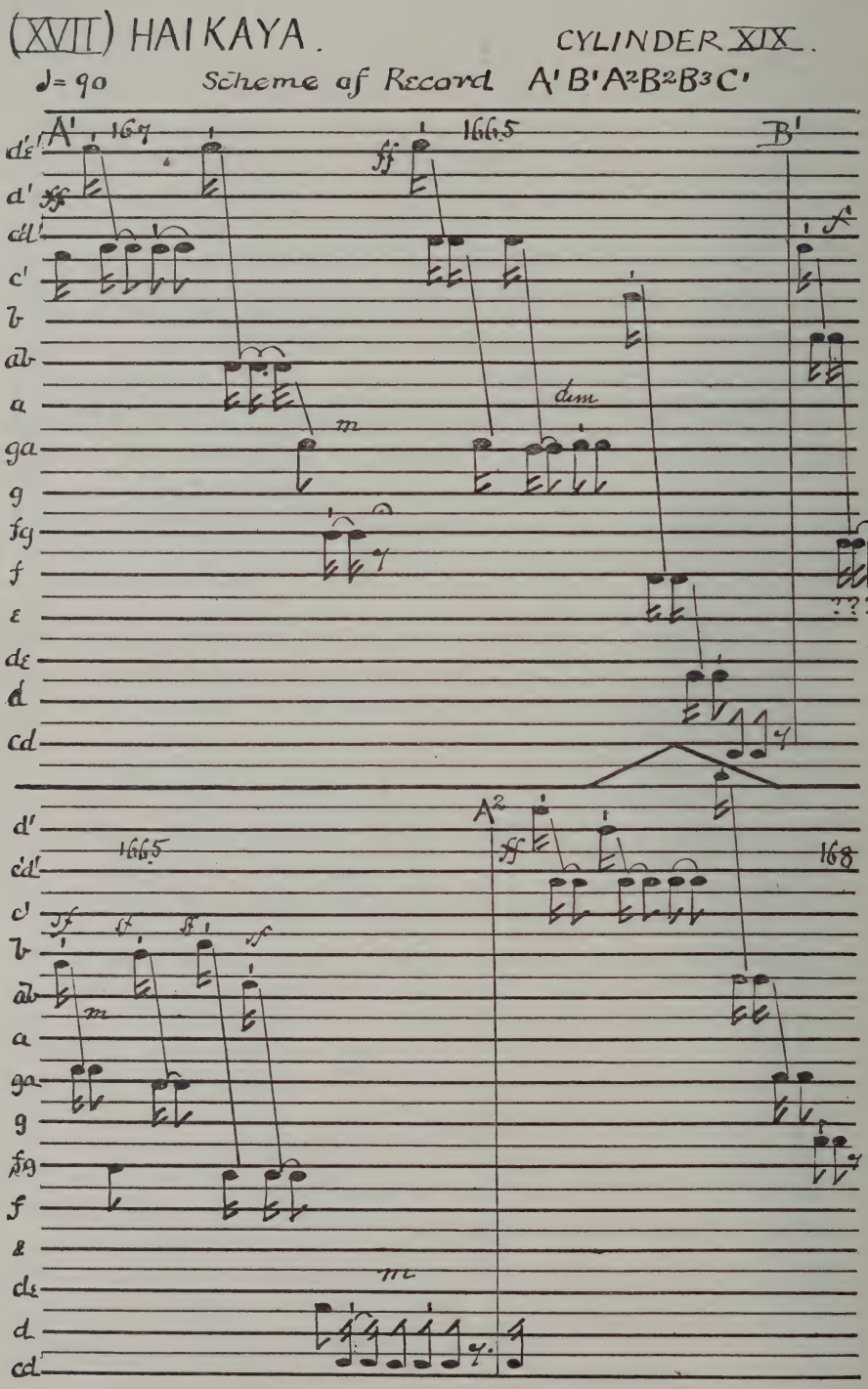
Quasi-major and minor readings occur. In B^1 δ is a major triad, in B^2 and B^3 a minor triad. The substitution of c for the first d of β in A^2 carries on the ampler movement of that segment partly due to

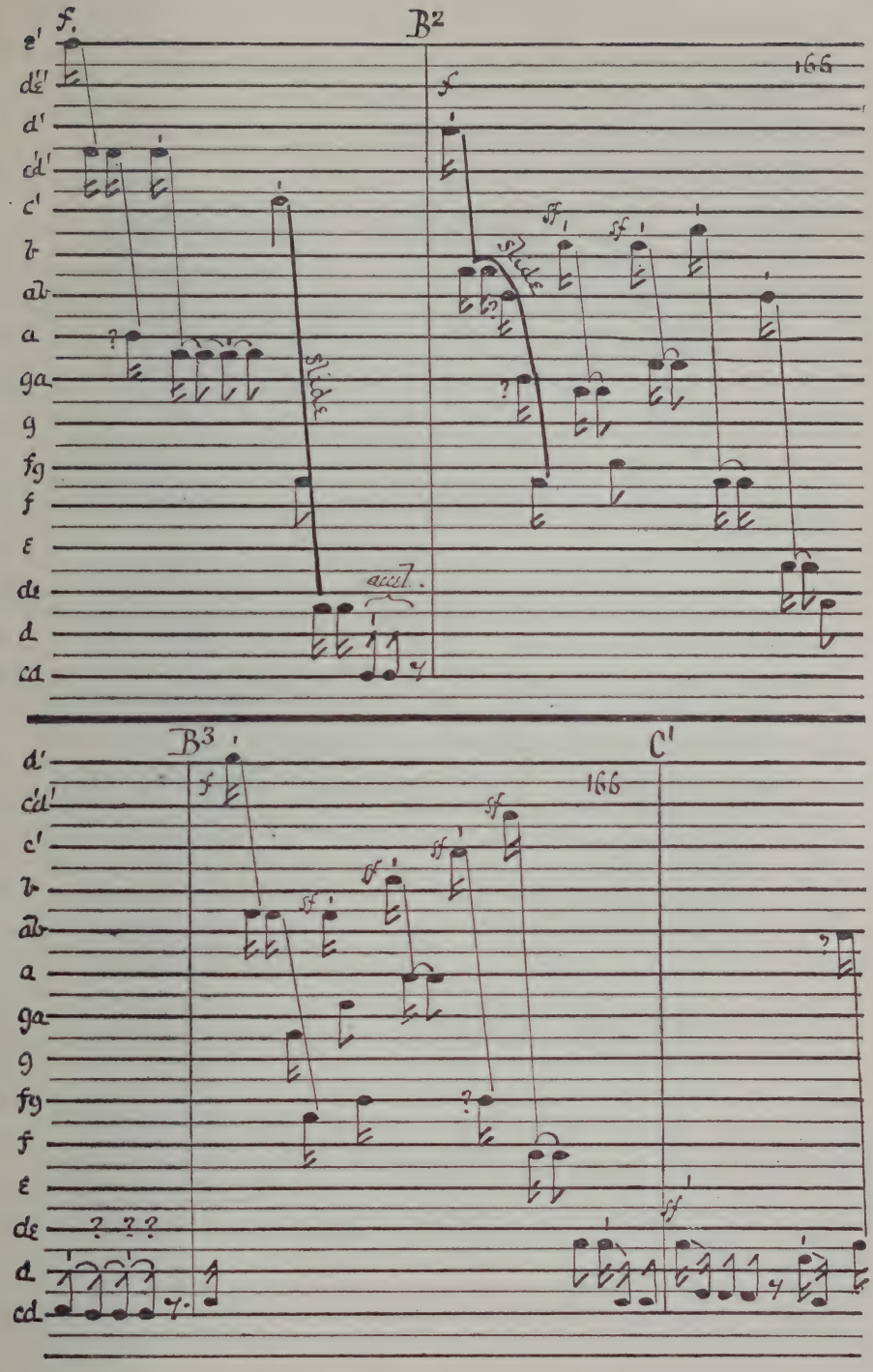
the shift, but we miss the lusty adiatonic d′e′ of A^1. The triads of ζ span approximate fifths in C^2 and consist of two major thirds spanning a minor sixth in C^1. Helmholtz speaks of the latter discordant combination (compare Snake Songs Nos. 2 and 3) as "sehr lehrreich für die Theorie der Musik" (Tonempfindungen, p. 352) because consisting wholly of intervals (c–e, e–$a^\flat$, c–$a^\flat$) accepted as consonances in the tempered scale, and explains the anomaly by an unconscious memory of the diminished and hence dissonant fourth that in true intonation combines with a major third to make a minor sixth. The disagreeable effect of the combination may also be explained diatonically, according to the diagram, as the union of parts of two triads of the minor mode, C–E–GA, demanding resolution into one or other; either C becoming B and giving the dominant triad, or GA becoming A and giving the tonic. In so far as this latter motive enters, the freedom with which the combination is executed in the present songs argues against a diatonic sense in the singers.

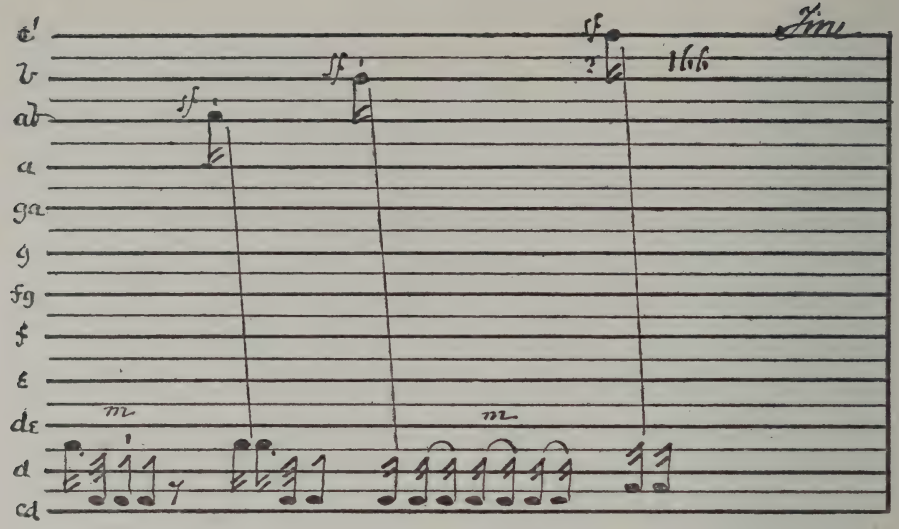
It is a constant temptation to neglect the anomalies of this music. Yet they contain its secret, as zero and infinity values that of a function.

HAIKAYA

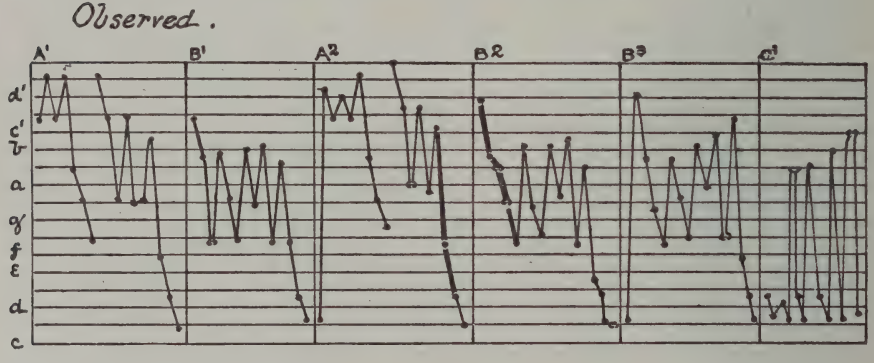


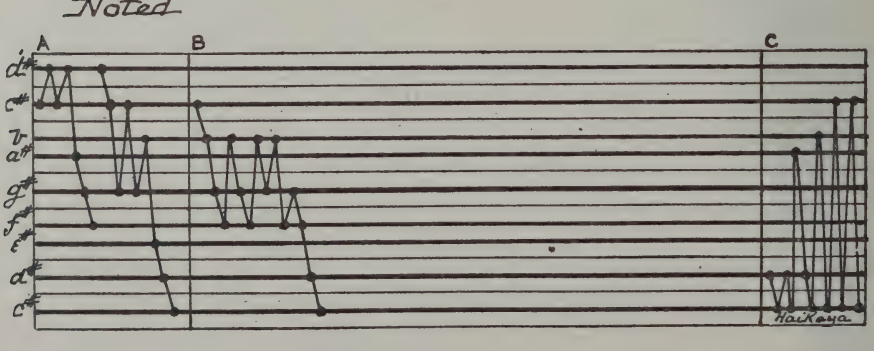

(XVII) HAIKAYA.
CYLINDER XIX.
♩= 90
Scheme of Record A' B' A² B² B³ C'
A'
B'
A²
dim
???


B2
B3
C1
166
166
Slide
Slide
accel.



COURSE OF TONE: HAIKAYA





ARGUMENT. A tetrad (d′e′–fg) prefaced by a tone (d′e′–cd) moves downward a fourth, the tone at first remaining stationary and holding the summit of the tetrad back a tone (at c′d′) and later moving downward itself a tone (to c′d′–b) and allowing the tetrad to resume its span (ab–cd).

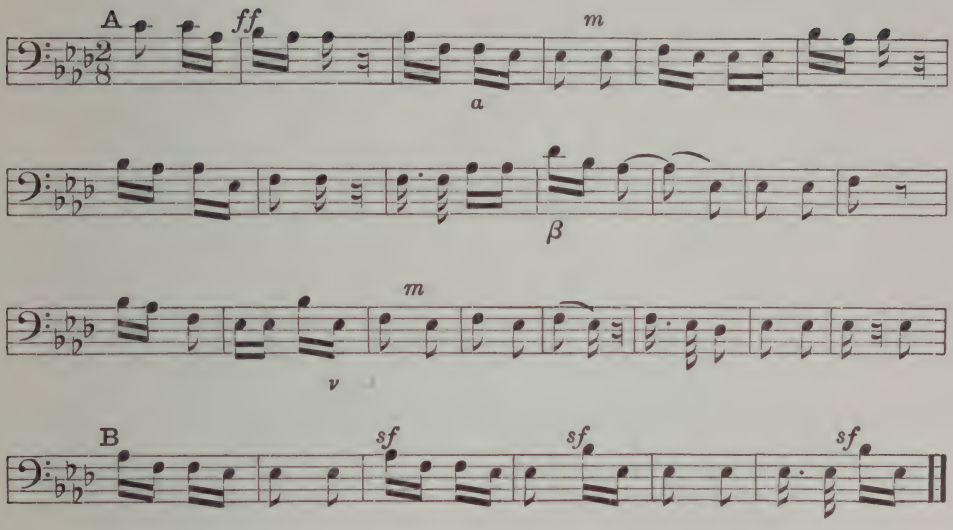
VIGOROUS in outline and even vociferous in delivery, the sobriety of structure of this little song is at the opposite pole of composition from the harlequin design of Jakwaina. Instead of numerous themes stated to be dropped, it presents a single one doubly developed. In A a fourth, d′e′–ab, prolonged to a minor sixth by the notes ga and fg, is expanded into a figure whose closing notes would repeat the previous close a fourth lower were the last rise a tone instead of an approximate major third. B develops this figure shifted downward a tone, shortening its final plunge to the initial minor sixth, and ending approximately on the same two pitches. C repeats these cardinal notes with sforzando leaps which start from the closing sixth (ab–cd) of B^1 and B^2, as it were pointing out the goal attained, and shape it elastically upward like the movements which in the preceding B^3 threaten to destroy the identity of that figure. The melody illustrates again the simultaneous shaping and expansion of figure shown in Anoshkaey, but gives the drama a different ending, the restoration of the figure to its initial span taking place by the delayed descent of the upper note instead of by shrinkage both ways.

Of the two lowest notes the upper is the more constant, only once in nine repetitions being judged to vary more than a fourteenth tone. The homologous note of the first figure of A^1 is judged at precisely the same pitch in A^2, the upper notes d′e′+ of the triads varying a fourteenth tone.

The final salient interval of the two A's if interpreted according to its actual span, which tends toward a major third, would overstep the limits of the key chosen for the whole song in the staff notation and is there registered as a minor third. It introduces a descent through a major seventh like that whose opening major third the ear could not overlook in β of Jakwaina, and has something of the same wild flavor. The adiatonic opening of all the repetitions — an approximate d′ reached

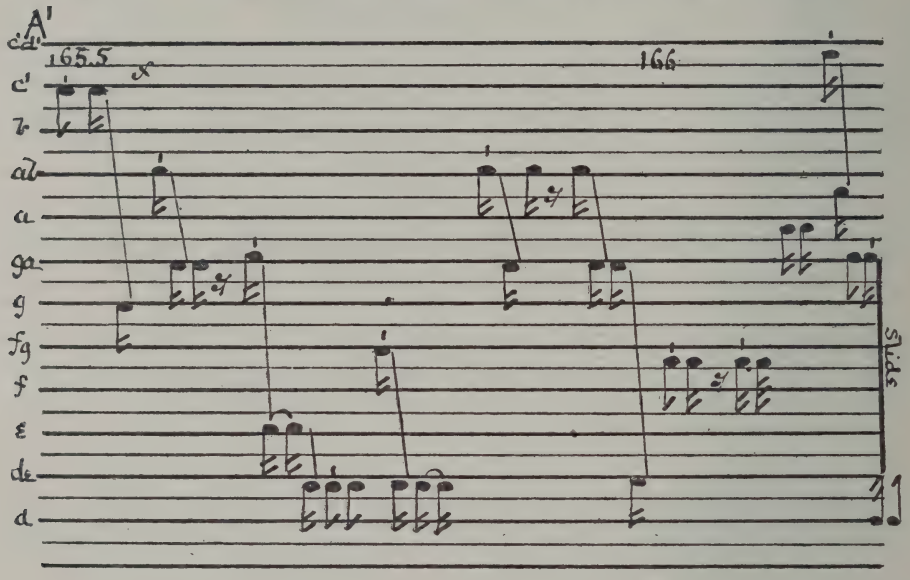
by a leap of a minor ninth — has the like crude pungency to our ears and was also not registered. To the singers these notes had doubtless no relief. They were not liberties but freedoms, instances not of license but of alternative propriety. They did not transgress, for there were no bounds to overpass in the singers' minds like the closed diatonic circle, only ways to choose between. Their unexpectedness to us is the warning unexpectedness of the turn in a writer's or speaker's expression that points to a meaning all along misunderstood.

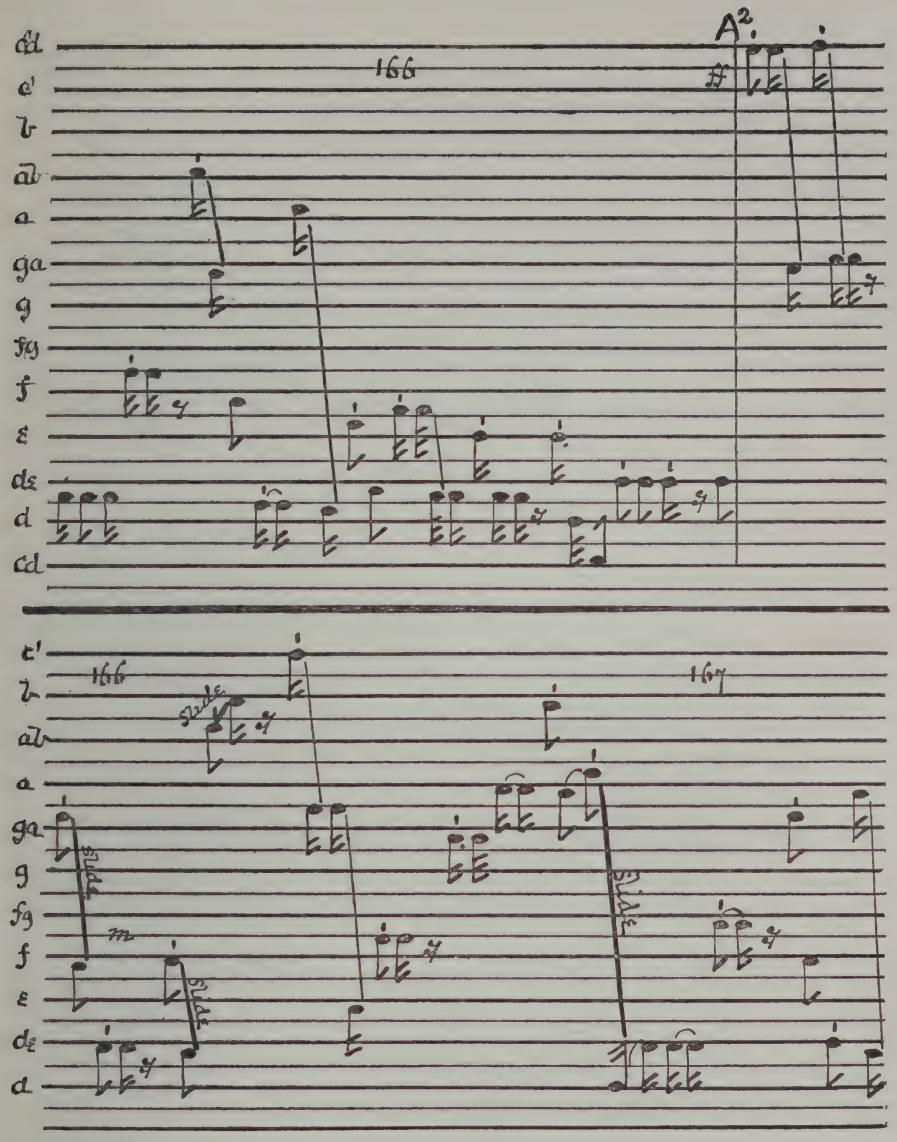
ANONYMOUS II

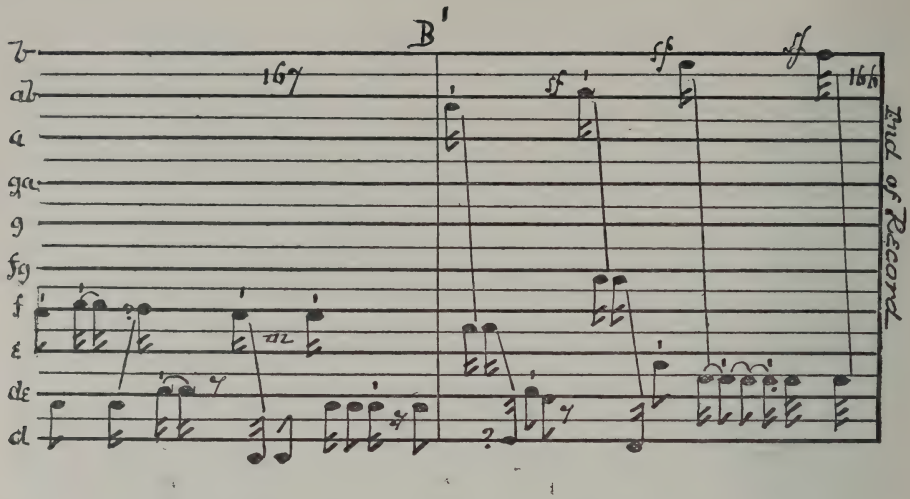


(XVIII) ANONYMOUS No 2 CYLINDER XIX (2d record)

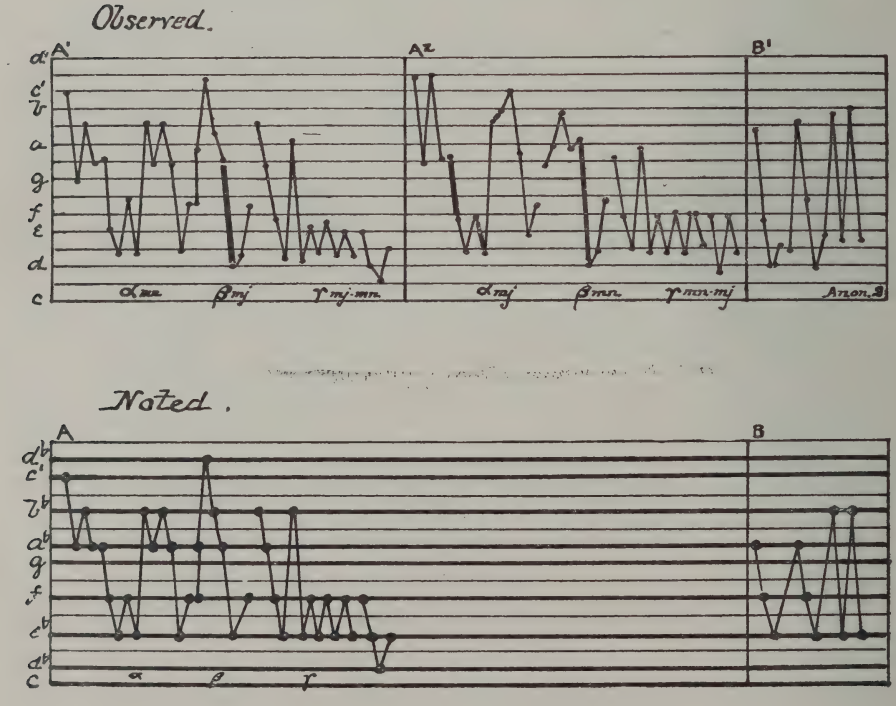
♩ = 80 Strongly accented. Scheme of record A' A² B'




A2
166
166
167
Slide
Slide
Slide
Slide



COURSE OF TONE: ANONYMOUS II



ARGUMENT. A trichord (c′d′–ab–ga) over a tetrachord (ga–fg–e–de) exchanges places with it.

AN ingenious little composition differing from Haikaya in its complexity and from Jakwaina in its unity.

The main field of the melody is divided in A^1 chiefly as a minor trichord over a minor tetrachord, and in A^2 chiefly as a minor tetrachord over a minor trichord. The resulting expansion in the closing interval of A is anticipated by alternate wider and narrower movements reducible as in Maihai-katcina to an inverse rhythm. The sequence is as follows:—

A^1 α minor – β major – γ major minor.
A^2 α major – β minor – γ minor major.

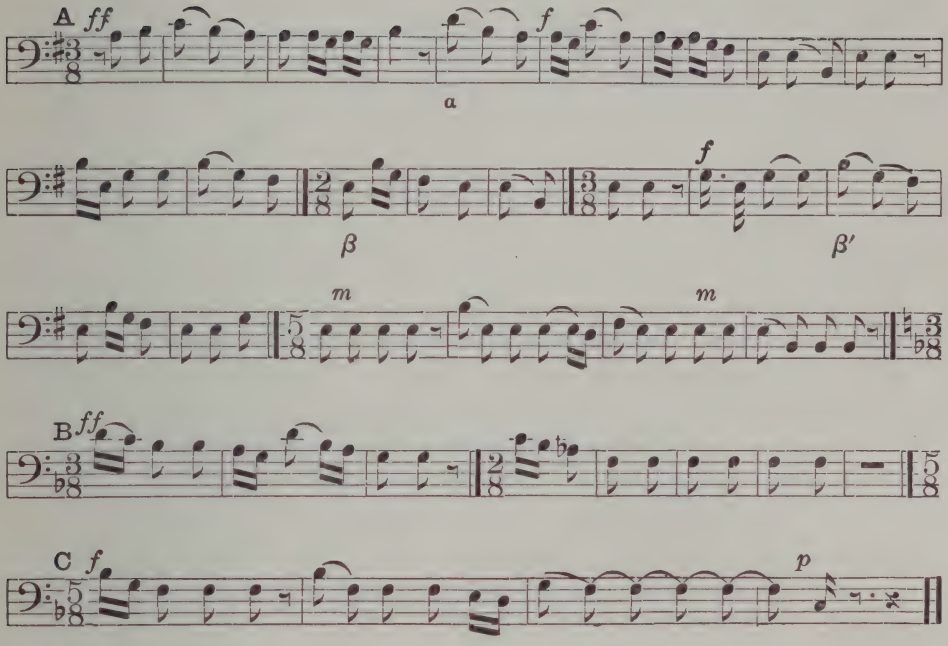
The three slides give α major a slower movement, and this is continued at the summit of β minor and the beginning of γ minor. B rehearses characteristic notes of the A's.

A^1 starts in α minor to climb to the upper fourth, c′d′–ga, which α major is to outline, by the zigzag path familiar in this music (compare C^2 and D^3 in Ço*y*óhim-katcina and θ in Jakwaina), but divides it trichordally at ab instead. The lower fourth it divides as a minor tetrachord by a semitone, e–de, and a minor third, fg–de, the division emphasized in α major by a slide of approach and another of departure being trichordal, by a tone, f–de. The fifth (ab–de) spanned in the final movement of α minor becomes in α major by a slide through a semitone, ab–b, a minor sixth; and a flourish before the descent through this interval lands the singer on e, a semitone above the pitch of the former α, which nevertheless he regains within a seventh tone in his movement to the final note. The two A's exchange character here, the bold movement of β in A^1 rising through a minor triad to complete the upper fourth as a minor trichord, c′d′–ab–ga, and its singularly diffident course in A^2, ga–a–b, reproducing the tetrachordal division, de–e–fg, of the lower fourth in α minor. A slide to the identical pitch d, setting a semitone lower limit several times struck to be immediately withdrawn from, is followed by recovery to the same pitch, fg–, within $\frac{3}{14}$ tone. The descent and

return with which γ opens are both wider in A^1, but in the course of that movement the rôles are again exchanged, the singer rehearsing in each case his initial division of the basal fourth, ga–de; in A^1 the semitone, e–de, in A^2 the tone, f–de. The genesis of the minor third in the final movement of γ is doubtless shown in A^2, where it approximately repeats the pitch reached by the foregoing slide; but the different reading in A^1 caused by the different span of the antecedent movements does not prevent the singer from striking the same final pitch within a seventh tone in the two A's. B follows, approximately repeating in the first movement the trichordal division at ab and f of the two fourths, the latter just rehearsed in A^2; and in the second movement their tetrachordal divisions at b, fg, and e; and combines with them notes at d outlining the lower penumbra of the main field of movement.

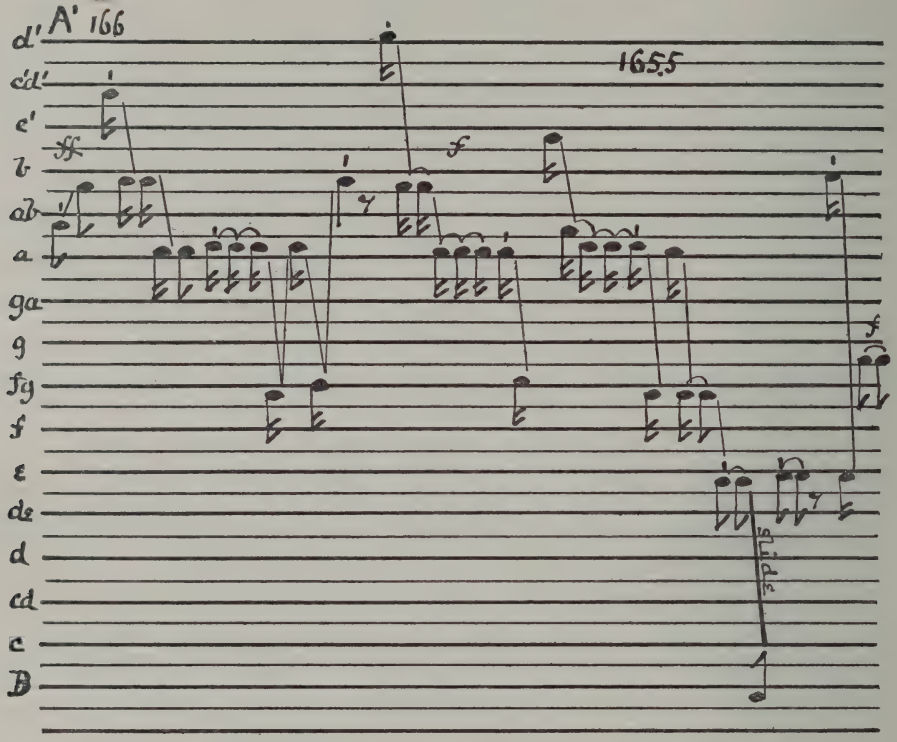
The figure of the song is conspicuously adiatonic. Mainly as the result of a mingling of trichordal and tetrachordal divisions, the pitches used are crowded together until but one space as wide as a tone is left unoccupied in either A. Notwithstanding this intricate departure from the diatonic norm, the staff notation records the song as one of the most unmistakably European of the series, electing to substitute for its wayward notes not always the nearest semitone of the key it suggested. Yet the flexible grace with which the slides of A^2 sketch out the movements laid down with more particular care in A^1 has not the air of blundering. The song is no fixed scheme in the singer's mind, but a composite memory of many free renditions, as a folk-tale in the mind of the narrator, minute exactness alternating with wide latitude in the recital.

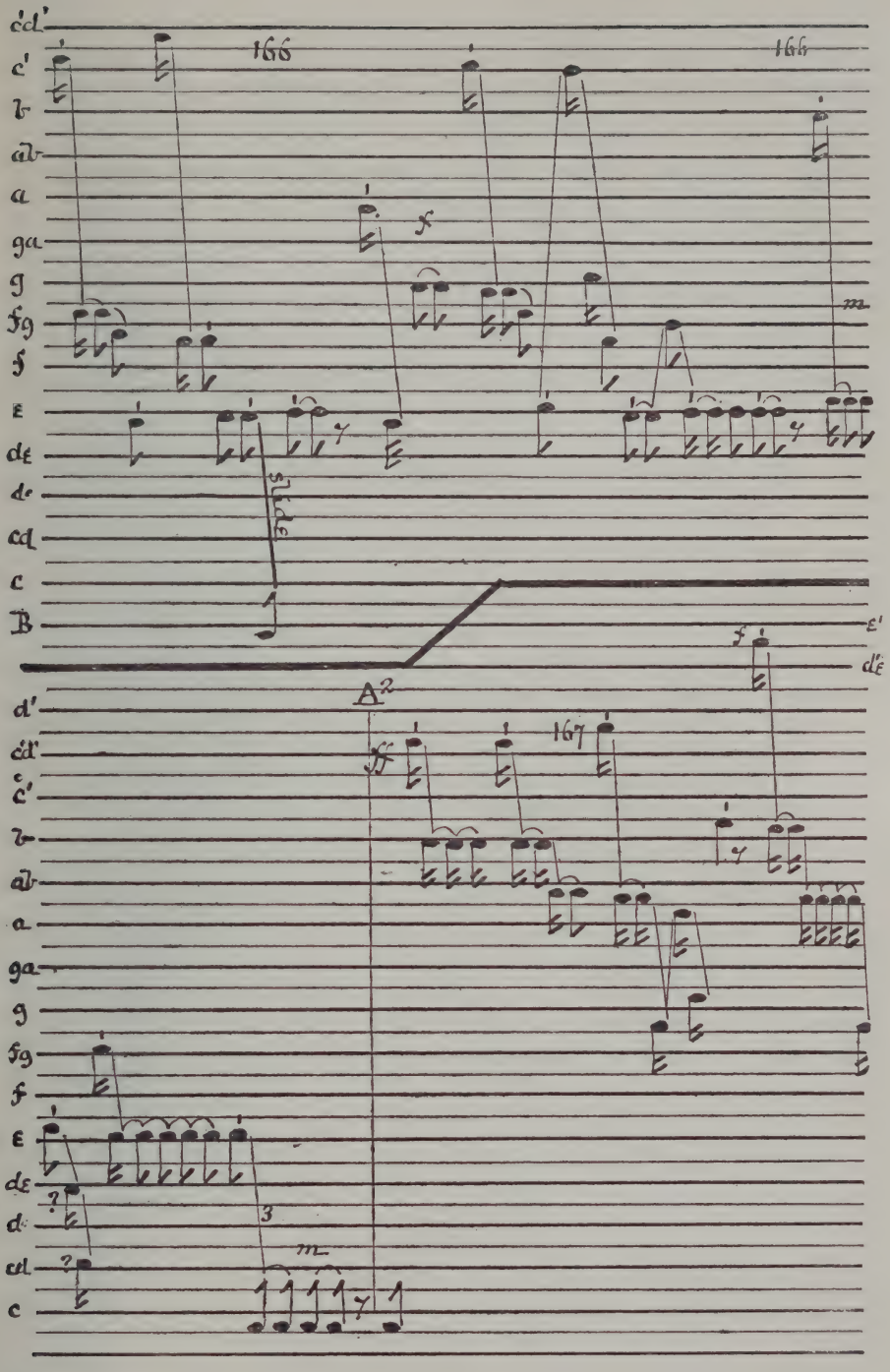
SUMÝACOLI

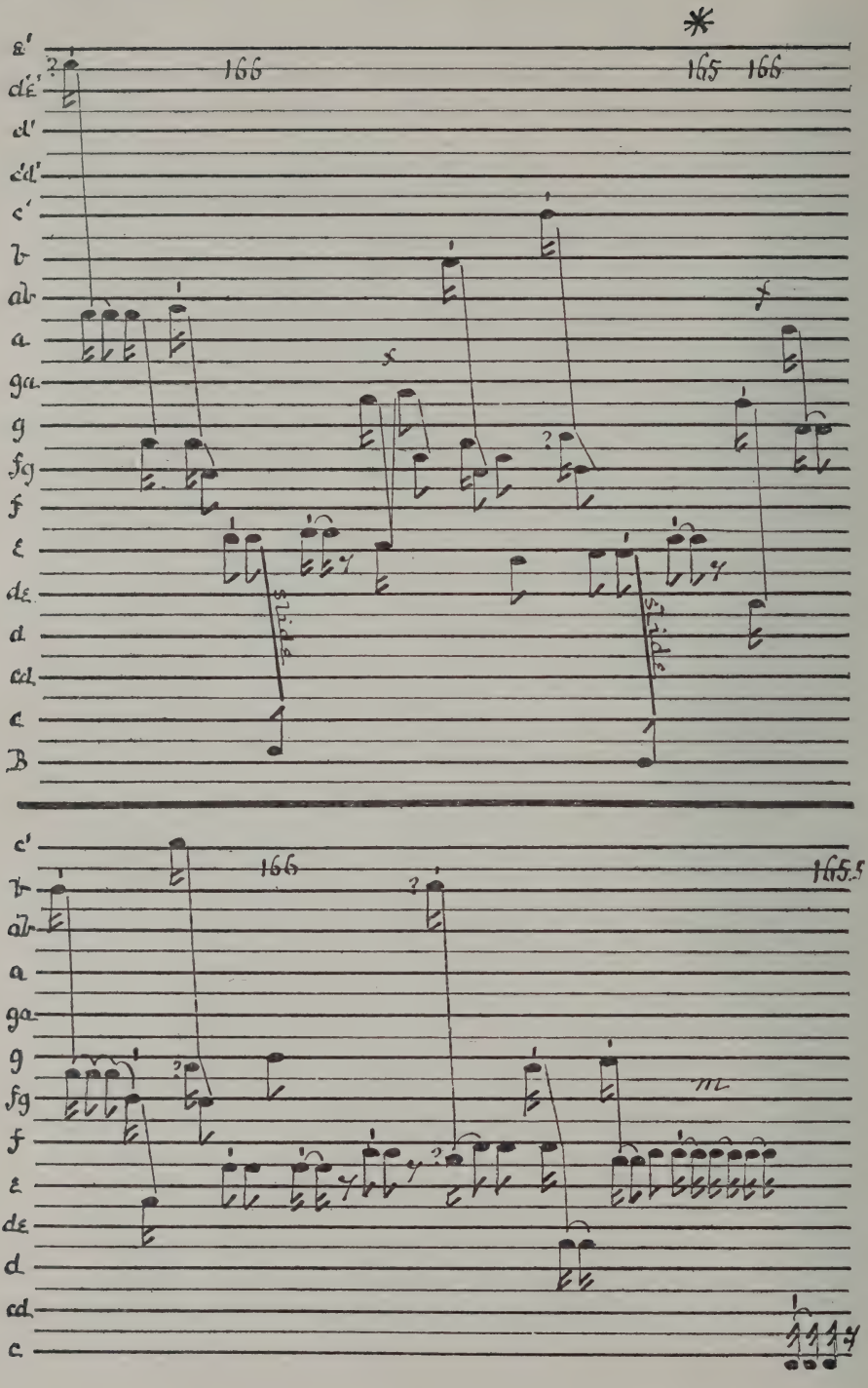


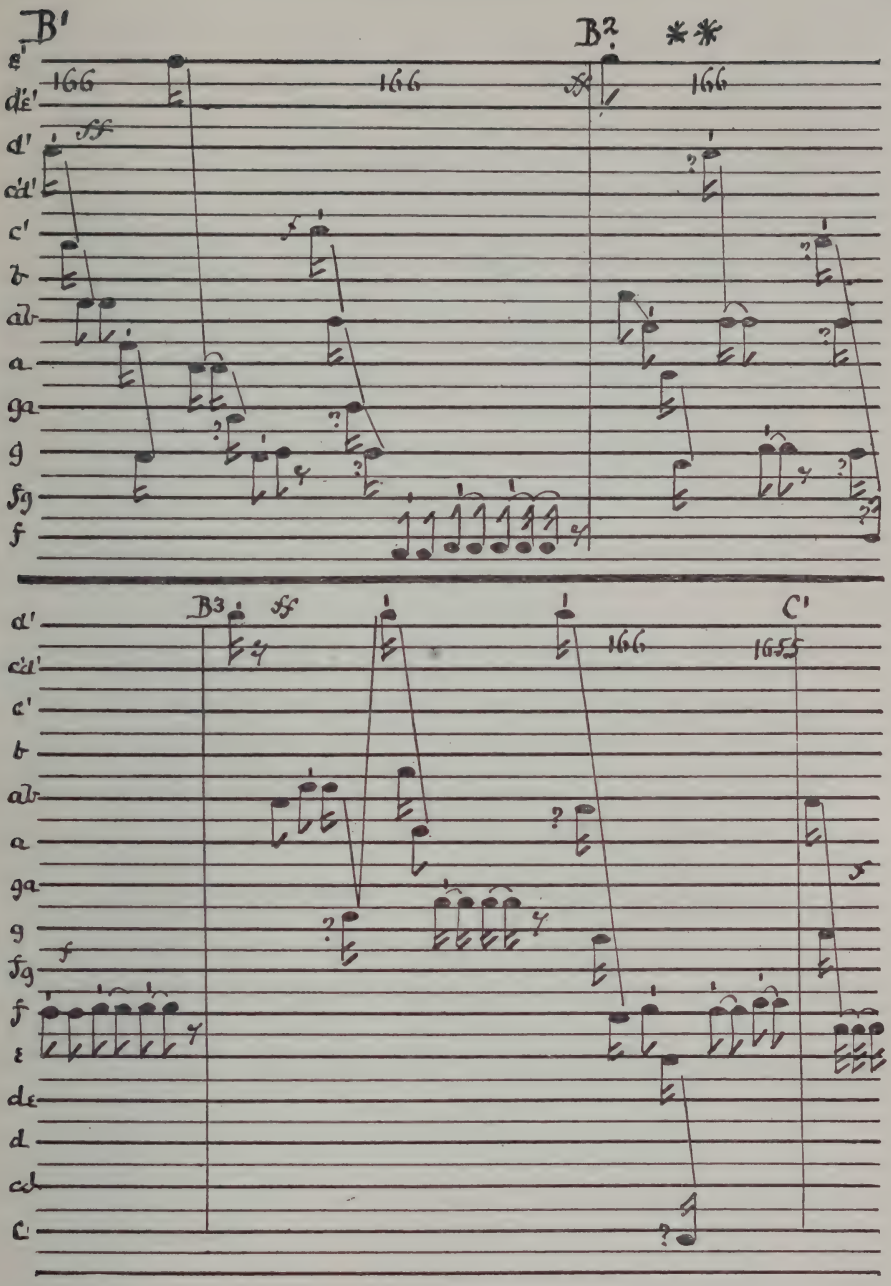
(XIX) SUMÝACOLI: sung by WiKyátewa. CYLINDER XXI.

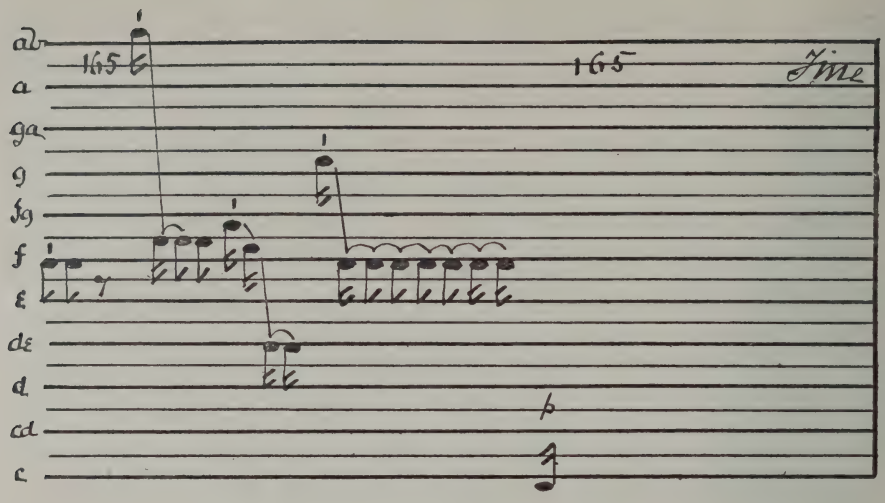
♩= 90 Scheme of record A'A² B'B² B³ C'.



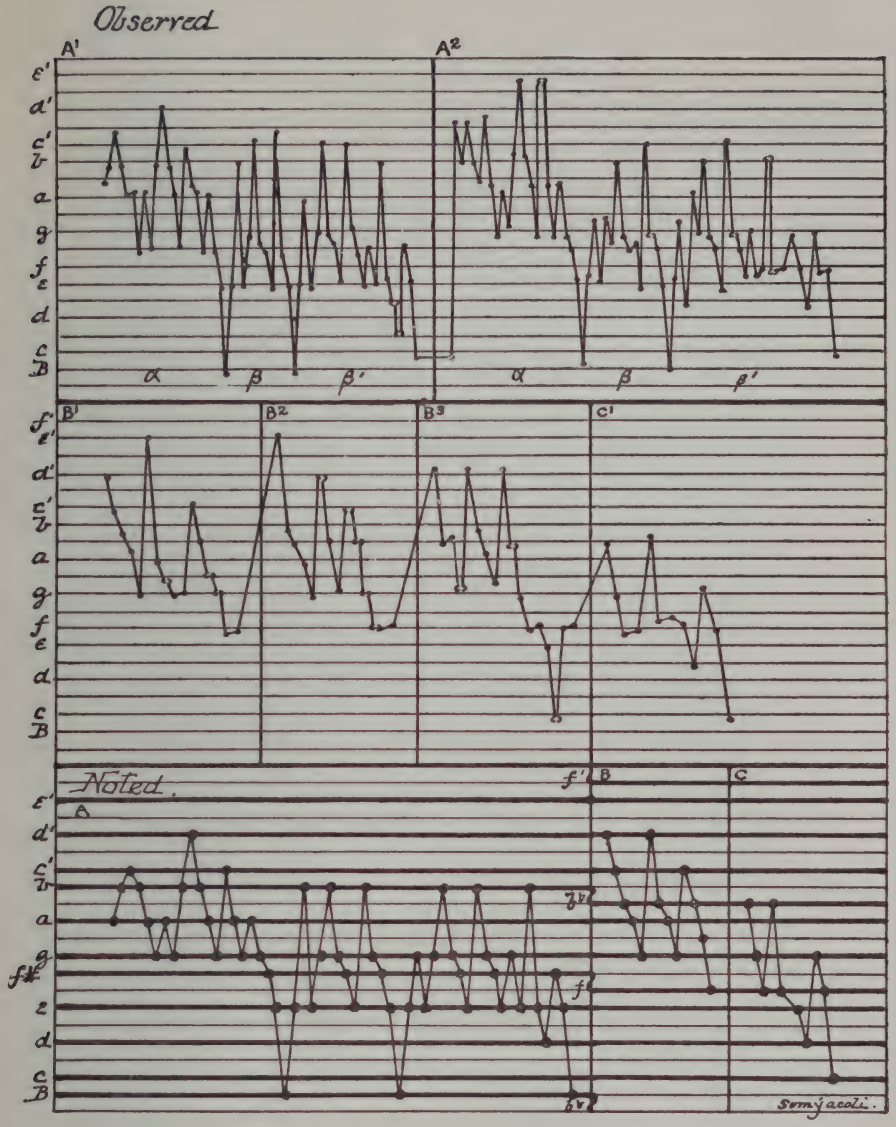

166
166
slide
A2
167
3


166
165 166
slide
slide
166
165.5


B'
B2
**
166
166
166
ff
f
B3
ff
C'
166
1655
f


165
165
Fine

COURSE OF TONE: SUMÝACOLI



ARGUMENT. The semitone partition upward (in β) of the mediant (fg) of a subminor triad (b–(g)fg–e) compresses a tetrad (in α) based on that note (c′d′–b–a–fg) and contracts the triad to a tritonus (c′d′–g, b–f), both regaining their span (d′–g, c′–f) by a semitone expansion upward.

THIS song makes a new and dramatic use of the serpentine lift of figure characteristic of this music, traversing the customary semitone in a more than usually complex way. The texture is woven and torn in A^1, patched in A^2, and displayed whole again throughout in B and C.

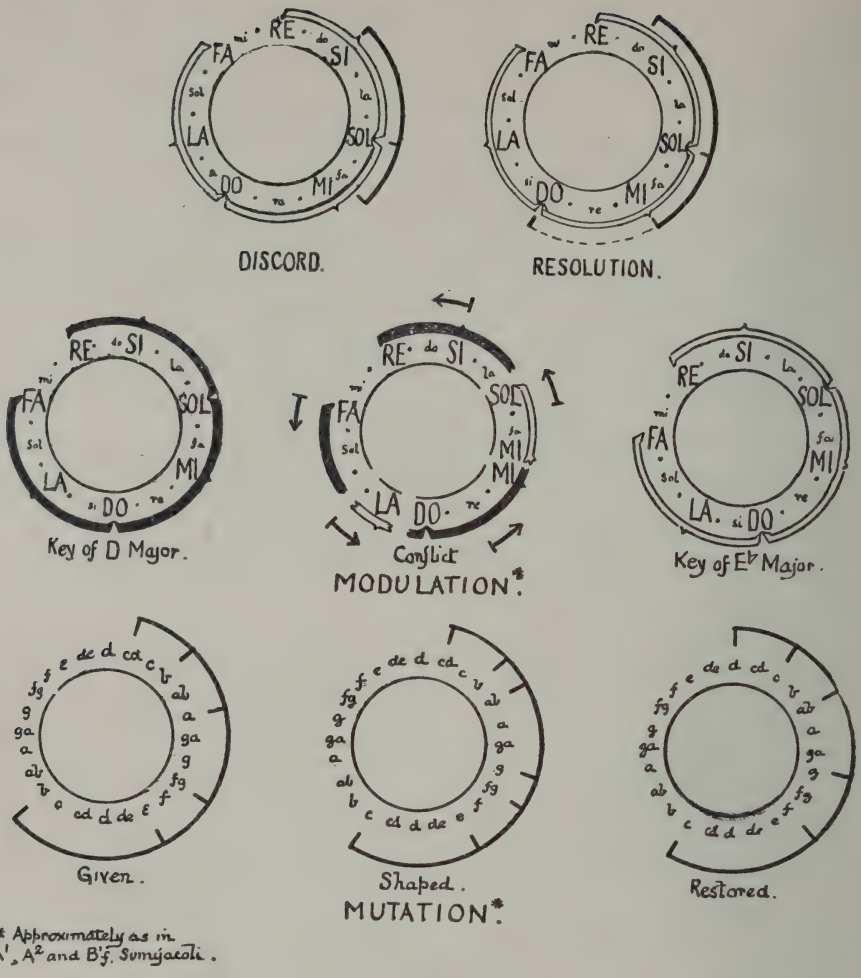
Downward excursions to octaves of previous notes divide A^1 into three movements, (1) α, beginning with the fifth c′d′–fg, (2) β with the fifth b–e, a tone below and hence divided into the fourth, b–fg, over the tone, fg–e, and (3) β' repeating the second with a coda. In all three of the movements the two fifths, upper and lower are immediately made sixths, the effort in β and β' expanding the tone, e–fg, to the minor third, e–g; and causing in the descent a duplication of boundaries (g, fg) which may be likened to a gap in the texture, as if the widening of the lower fifth had been produced by raising its upper fourth a semitone and leaving the tone below intact, as in A^2 of Shiashtasha, Singer No. 2. The final note of A^1 shows the influence of this lift, being the octave of the new upper boundary, c, of the lower fifth, originally b–e. The singer then traverses his course again, devoting himself to the orderly adjustment of the original figure to the new internal boundary, g. He first reduces the span of the movement of α from the original fifth, c′d′–fg, toward the tritonus, c′d′–g, not forgetting to visit the old boundary, fg, in his closing downward excursion. Thereupon he rehearses β and β', making the rent in the texture more conspicuous than before, until at the final rise just before the coda he identifies the upper limit of the original tone, fg–e, with the new lower boundary, g, of the original fourth, b–fg, thus closing the rent by making the lower fifth, b–e, also a tritonus, b–f. He then ends as before on the octave, c, of the extension of this interval, within a fourteenth one of the pitch which closed A^1.

The texture at this point consists of the two original fifths (upper, c′d′–fg; lower, b–e), both shortened to tritonuses by raising the same

note, fg, to g: this alteration being external compression (c′d′–fg to c′d′–g) in the case of the upper fifth and internal repair in the case of the lower (b–g–fg–e to b–g–f); both tracts nevertheless existing as fifths (d′–g; c′–f) by the penumbral extension from which the change arose. There remains only to resolve this novel kind of discord — this untenable figure not *within* a framework but *of* a framework — by proceeding to the suggested fifths, d′–g, c′–f. This the singer does in the B's and C with a vigor and iteration that recall the long felicitations of the close of "Fidelio." The upper fifth, d′–g, is exhibited in all its possibilities of charm, divided all ways by thirds and fourths, the initial descent of B^1 already anticipating most. The lower, c–f, is gradually dismounted interval by interval, the octave echo of its upper limit becoming the close of C^1 and of the song, within a fourteenth tone of the pitch at which it was first announced in A^1 and at the identical pitch with which it closed A^2.

Surprising and even hardly credible as this intricacy sounds, the interpretation does not depend on the evidence of this song alone. It is a link in a chain of evidence of an instinctive preference for elasticity of form to which nearly every song of the series contributes. Separately the inferences to the use of this device as an artistic motive seem doubtful; collectively they seem to present under the aspect of a deliberate plan which really was the spontaneous choice of the singer.

The diagram on the following page shows the relation between two chief means of effect in European music, discord and modulation, and the mutation of figure illustrated again in Sumýacoli. The continuum of tone is represented as a circle, in which the octaves of any given pitch alternately occupy opposite ends of a certain diameter, movement against the hands of a clock being upward. As in the previous diagrams of the modes, the diatonic scale is represented by three brackets in contact signifying any combination of seven pitches spanning three fifths, chosen from the alternate octaves represented by the points on which the ends and medial points of the brackets fall, and standing for the tonic, dominant, and subdominant chords in the order in which the European musical consciousness finds them balanced.



Discord is any combination of pitches within the diatonic scale other than the notes of one of its three triads with their octaves, and *resolution* the sequence of some combination of these upon the discordant group. In the resolution represented, the upper octave of the tonic represents it. *Modulation* is a change in the conception of the step of the scale represented by a given pitch, entailing changes in the pitches identified with other steps of the scale. It appears in the diagram as a revolution of the triads about the axis of tone. The modulation from D to E♭ is shown as a backward rotation (ascent) of the scale through 15°, Si coming to occupy the place of Do. *Mutation* of

figure is the repetition of a melodic phrase with certain of its notes displaced. In this music the displacement commonly does not exceed a semitone, is often upward, generally affects all the notes approximately of a certain pitch, and is apt to be followed as it is in Sumýacoli by a similar movement of the rest of the notes. In illustration suggested by the present song the interval order of the original movement, in semitones from below upward, is 5.2.3.2.2; and this is shaped to 4.2.1.3.1.2, reverting to the first sequence at a semitone higher level.

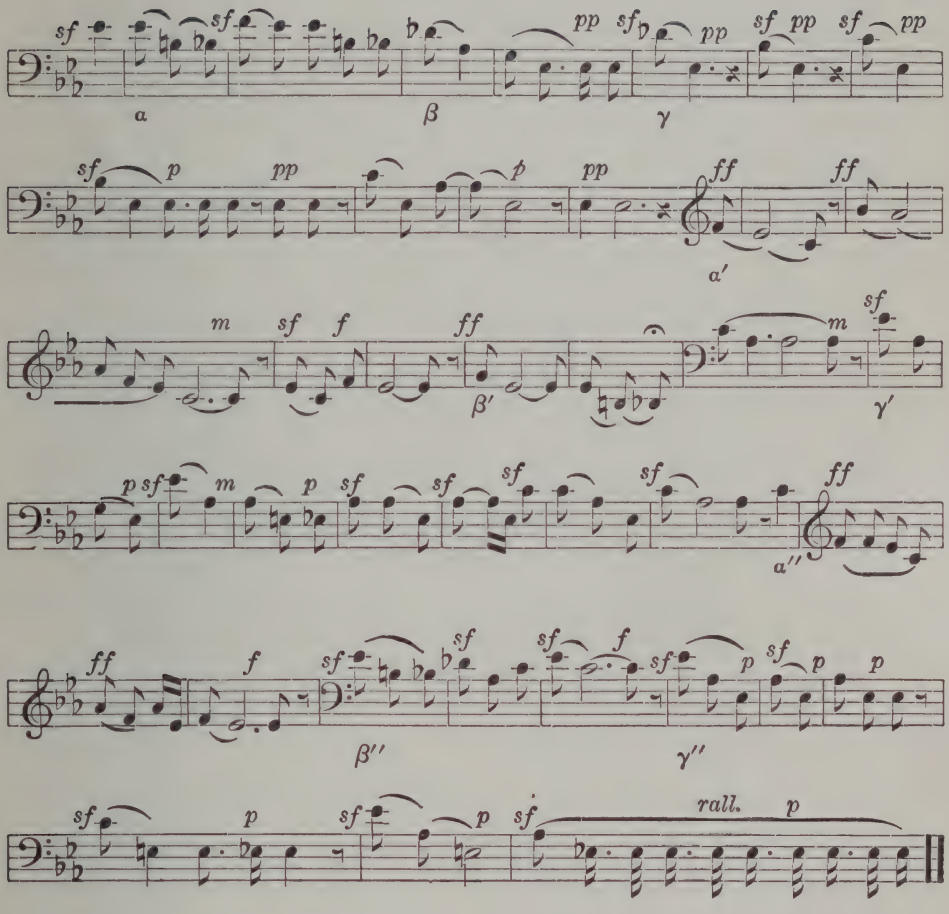
(1) Mutation has points of resemblance with both discord and modulation. Like resolution, the restoration of figure has the form of a return, of expectation satisfied. Commonly it is like modulation in altering the pitch of the figure. Otherwise it differs from both. Both involve a scale, to whose structure resolution adjusts divergent combinations of pitch, and whose steps modulation shifts from one pitch to another. Mutation is hardly compatible with the hypothesis of scale. The central diagram illustrating the conception of fragmentary modulation, of zones of tone simultaneously referred to different keys, makes its improbability visible. Here the arrows show that the outlined fragments of the scale have completed their journey, the black having theirs still before them. (2) Discord and mutation are mutually independent. Resolution does not involve restoration, but might wholly differ from either the discord or preceding concord. Restoration does not involve resolution, for it may reproduce a discord which the shaping resolved. (3) Modulation and mutation are likewise independent, a modulated figure being shaped or not at will, and a shaped figure often reverting to the original pitch. (Snake Song Nos. 1 and 3.)

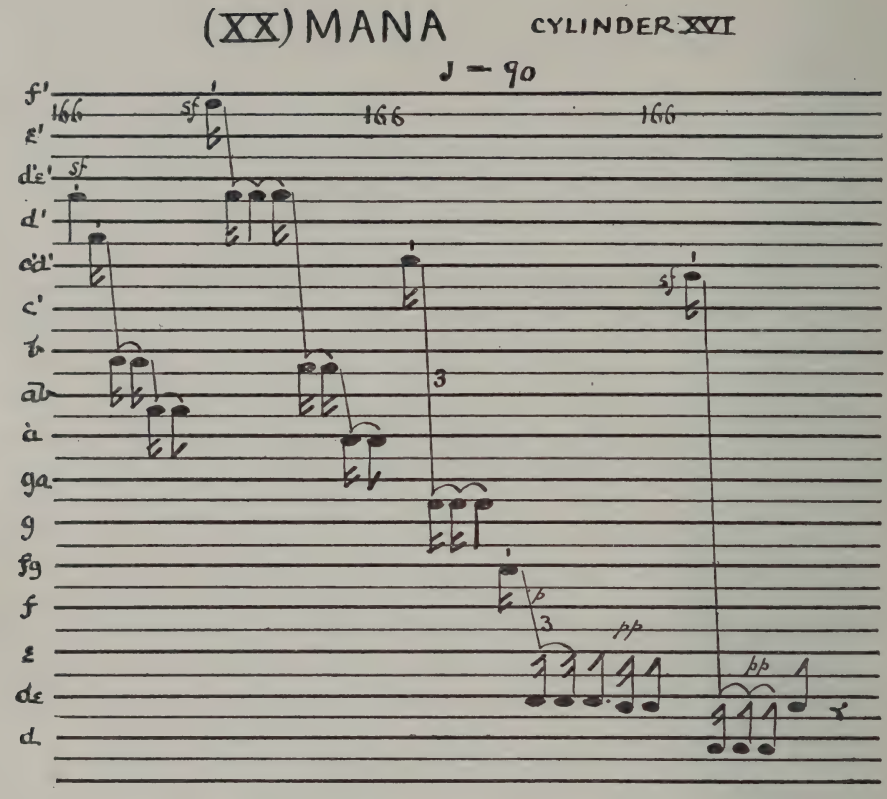
In these essential respects mutation of figure is a different means of musical effect from either of those upon which European music is largely based. The shaping of minor melody by repetition in the major mode ("La Marche des Rois" from the overture to "L'Arlésienne"; "Prayer from Moses in Egypt"), since it always affects the same steps (often but one) of a complex otherwise invariable, instead of any note of varying complexes, is a special case of the device in

which the Hopi singers apparently find an outlet for their emotional vivacity and instinct for novelty.

In the staff notation Sumýacoli is dull, as mother-of-pearl would be dull in a color-print. The gap, g–fg, in the lower fifth of A was noted, and the upward shift in B, but neither the origin of the former in the penumbral c′ of β nor the motive of the latter in the two tritonuses. The pitch of the upper fifth was misread and the final modulation upward represented as a return to it instead of an ascent from it. In a word, what with much confidence may be asserted to be the spirit of the song, or a prime essential in its spirit, does not survive the Procrustean mutilation of its form to which the diatonic consciousness unwittingly subjects it. We learn again the lesson that, venial fault as it may (or may not) be in an agent of European civilization to dress non-European men and things in the garb of Christendom before he has further to do with them, it is the unpardonable sin in a critic aiming not to mould native life but understand it.

MANA


sf sf pp sf pp sf pp sf pp
α β γ
sf p pp p pp ff ff
α′
m sf f ff m sf
β′ γ′
p sf m p sf sf sf sf ff
α″
ff f sf sf f sf p sf p p
β″ γ″
sf p sf p sf rall. p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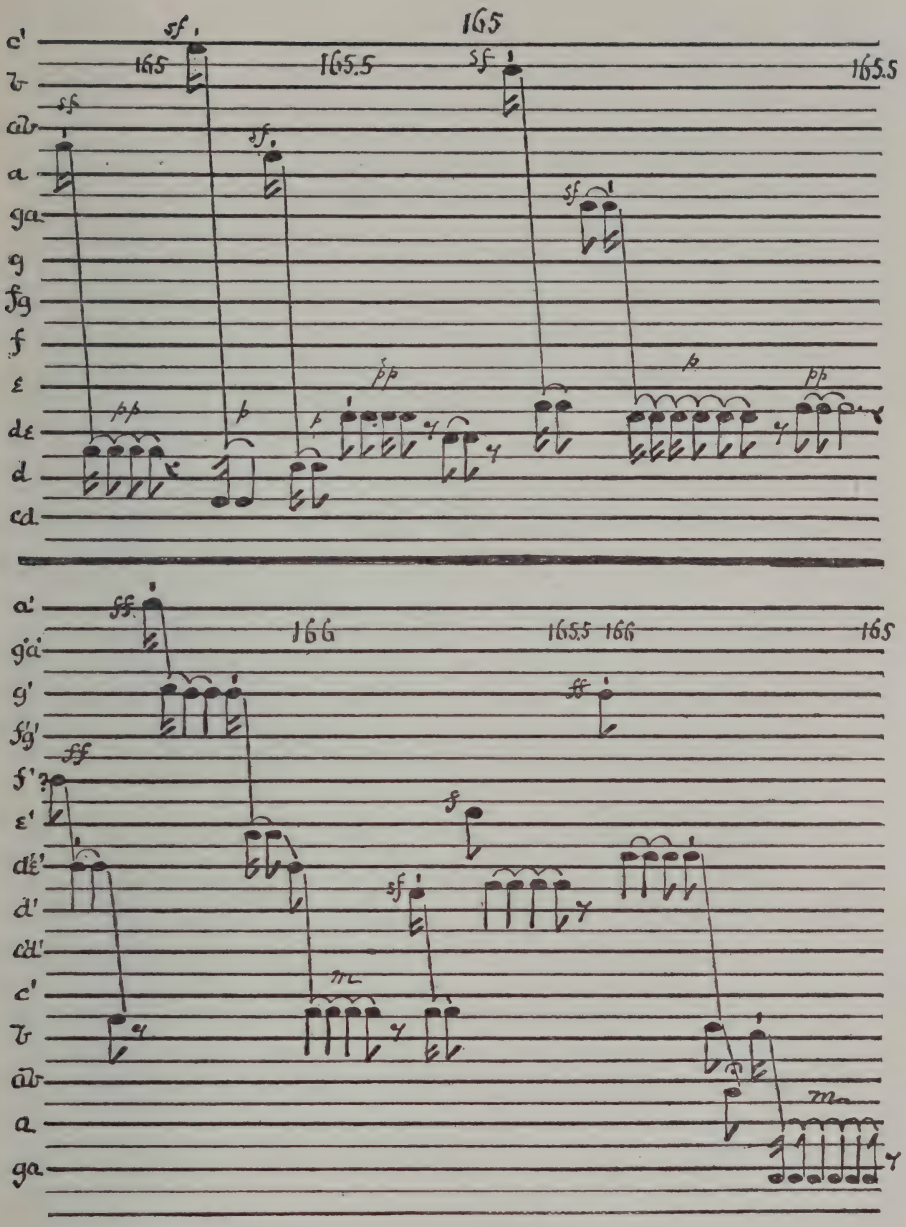
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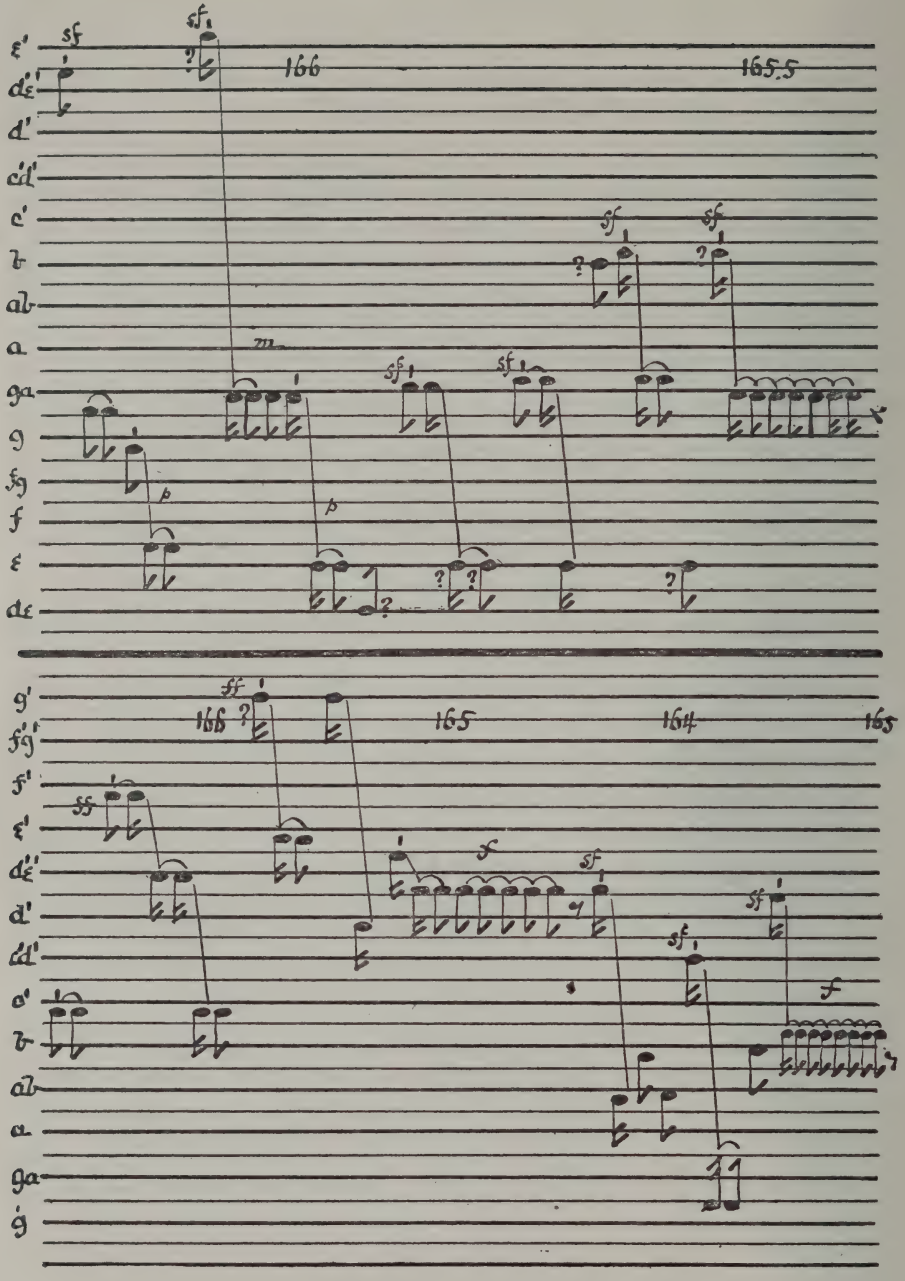
165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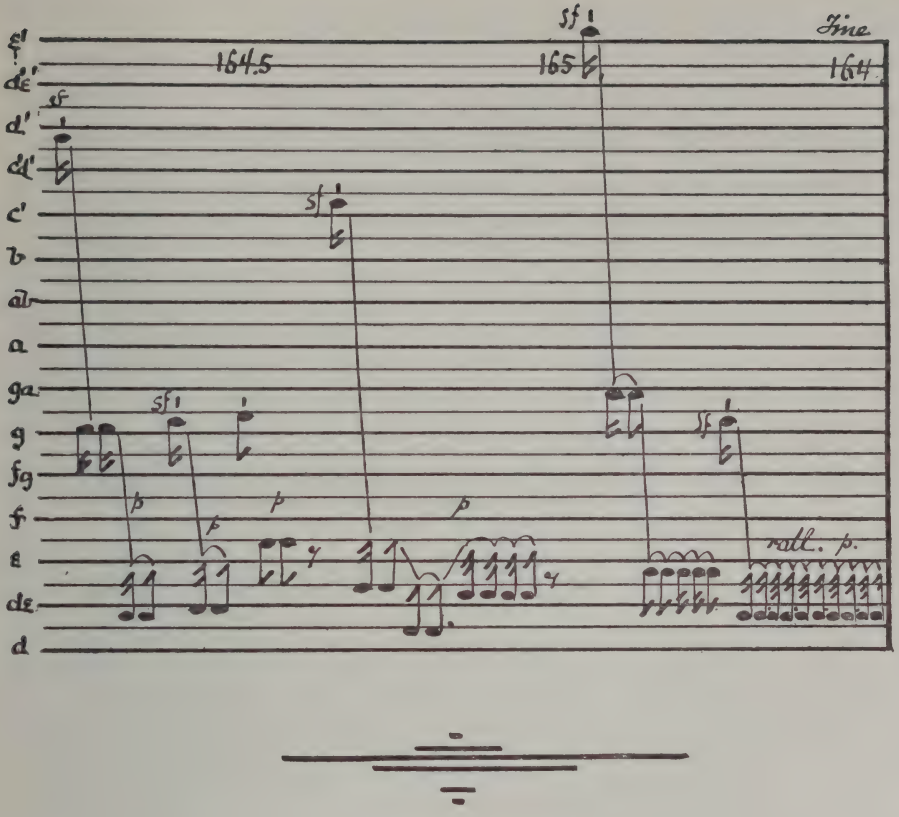
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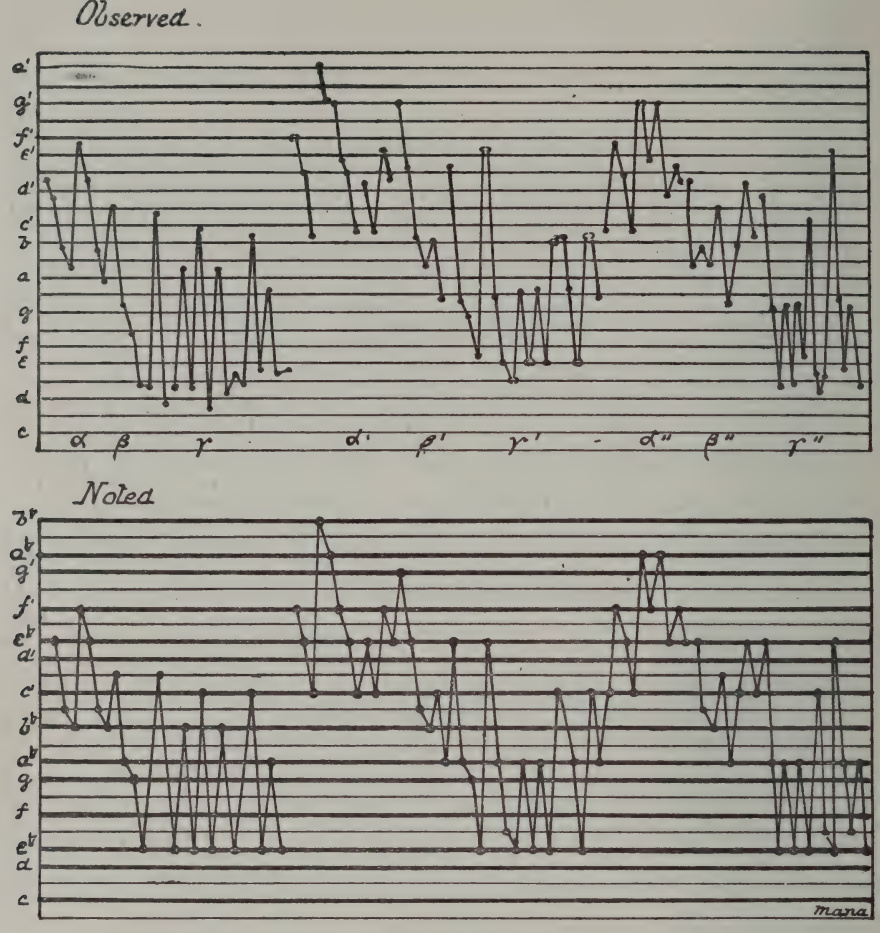
rall. p.

COURSE OF TONE: MANA



ARGUMENT. A tetrad (f′–d′e′–b–a) contracted upward to a major trichord (f′–d′e′–b) gives place to triads (g′–d′e′–b, b–(ga)g–e(de)).

THE wailing irregularity of Mana gives it a place apart in the series. It presents *disjecta membra* of this music, a passion in tatters.

Two major triads appear, separated by a semitone (g′–e′–c′ : b–ga–e), the upper alternating with a major trichord (f′–d′e′–c′); and on other lips this or some other structure might be more definite. The present performance chiefly impresses by imaging in the contracted span of some movements the attitude of sorrow, and in the violence or abandonment of others its bearing.

Through the dissolving form of the song three segments can be discerned, each presenting the familiar outlines of a high movement, α, a descent, β, and a coda, γ: the singer closing within a fourteenth tone of the lower octave of his opening note. Both the form of the song and its adherence to pitch appear more precise on closer examination. One chief refrain is discoverable in all the α's; the β's reveal an identity, and β'' copies the close of γ'. The opening movement of α'' marks out an exact major trichord; α' begins with a redundant one at approximately the same pitch, thereupon modulated upward a major third and repeated a moment later, its components in a new sequence. The extension of a major trichord to a tetrad by a pendent tone is already illustrated in this music (Maihai-katcina, A^3, Sumýacoli, B^2); and to this more complex group the singer gives a languid approximation, compressed within a fourth, in the initial movement of the song, forthwith lifting up his voice to a more vigorous reading spread to a sixth. Rising a major third, he then descends two fourths in β, the first empty, the second a nearer approach to a major trichord than he has yet attained. In α' he recommences the tetrad theme at the pitch and with the span of the previous bolder rendering, but rests on its second interval as if without heart to finish; and rising a major third above its highest note, re-performs the same broken combination, first in the more vigorous and then in the more languid form, after another moment of hesitation substituting for the latter a varied reading of the fuller type. The same rise of a major third which led from α to β now leads from α' to β', the following descent spanning a semitone more than β, and augmenting its time in a still larger ratio. The major triads that succeed in γ', and are reflected in β'', brighten the melody for the moment. Taking up in α'' the same incomplete refrain at the same pitch, the singer develops it into a minor trichord at a tone above (g′–e′–d′) the same interval of advance that separates the initial movement of the song from its repetition. Thereupon in β'' he executes two downward fourths, not superposed as in β, but lapped and apparently complicated by a dependence on previous pitches. The song ends in γ'' upon the final major triad of γ' extended nearly to an octave.

The alien artistic methods which Verdi divined and has idealized in the chromatic cadences of "Aida" here present themselves in real life. In the third movement of a' the main theme is given in a form which almost exactly reproduces the motive "Numi pietà" — also a lament — from the first act of that opera.

In Mana the sense of interval yields to the need of utterance. The melodic intention still persisting is hardly more than is inseparable from the use of the familiar melodic means. The boundary between music and speech is near.

THE HEMENWAY SOUTHWESTERN EXPEDITION

By Benjamin Ives Gilman and Katharine H. Stone

THE HEMENWAY SOUTHWESTERN EXPEDITION

In closing the final volume of the Journal of American Ethnology and Archæology we desire to add the following account of the active support given by Mrs. Hemenway for many years to the study of American history and archæology.

In 1879 Mrs. Hemenway's gift toward the purchase of the Old South Church in Boston made possible the permanent preservation of the building as a historic monument, and the work of instruction in American history since carried on there owes its foundation and maintenance to her. In 1882 the visit to Boston of several Zuñi Indians under the guidance of the late Frank Hamilton Cushing of the Bureau of Ethnology, since 1879 identified with the study of this people, impressed Mrs. Hemenway with the need of securing accurate information about the tribes of the Southwestern United States before it should be too late. At Mrs. Hemenway's invitation Mr. Cushing visited the East again in the summer of 1886 with three Zuñi chiefs, and in the autumn was commissioned by Mrs. Hemenway to continue the studies of the Pueblo Indians which he had already carried farther than any predecessor. The title of the Hemenway Southwestern Archæological Expedition was the suggestion of Mr. Cushing, who became director of the work, with Mr. Frederick W. Hodge, now of the Bureau of Ethnology, Dr. J. L. Wortman, of the Army Medical Museum, and the well-known archæologists, Dr. Herman F. C. ten Kate and Dr. Adolf F. Bandelier, as assistants. In February, 1887, investigations were begun on the Rio Salado near Phœnix, Arizona, and early in 1888 were taken up at Zuñi. The greater part of the pottery and other finds at both places are now included in the collection preserved in the Hemenway Room at the Peabody Museum of Harvard University. In 1888 the Expedition was represented at the Seventh Congress of Americanists in Berlin by two of its advisers, Professor E. S. Morse of Salem and Mr. Sylvester

Baxter of Boston. A typical collection of pottery, mostly from the Rio Salado, was shown, and this was later presented to the Imperial Ethnological Museum in Berlin by Mrs. Hemenway. At this time Mrs. Hemenway actively interested herself in the preservation of the remarkable ruin called Casa Grande in Arizona, and joined in a petition to this end which was presented to Congress on February 4, 1889, and granted March 2, the ruin being at present a national reservation. The study of the history of the Pueblo tribes occupied Dr. Bandelier until 1891, and a collection of books and copies of MSS. brought together in the course of his investigations was presented by Mrs. Hemenway to the Library of the Peabody Museum.

In July, 1889, the charge of the Expedition was transferred to Dr. J. Walter Fewkes, now of the Bureau of Ethnology in Washington, already well known as naturalist and ethnologist. In the winter of 1889–90 Dr. Fewkes was commissioned by Mrs. Hemenway to visit the Passamaquoddy tribe of Indians in Maine, taking with him a phonograph in order to test the availability of this instrument as a means of collecting the folk-lore of the Pueblo tribes. The results obtained led to the inclusion of a phonograph in the outfit of the next expedition to Zuñi, where a number of records were made both of speech and song. The cylinders were afterward deposited in the Peabody Museum, the study of the songs being intrusted by Mrs. Hemenway to Mr. Benjamin Ives Gilman, now Secretary of the Museum of Fine Arts in Boston, at the time lecturing at Harvard University on the psychology of music. During 1890 and 1891 the late Mr. John G. Owens was associated with the Expedition. Mr. Owens was the first incumbent of a fellowship in American Archæology and Ethnology instituted by Mrs. Hemenway in pursuance of her plans for the encouragement of these studies, and held the position until his death in Honduras in 1893 as chief executive officer of the Peabody Museum Expedition to that country. In 1891 the Expedition removed from Zuñi to the Moqui or Hopi villages in Arizona, the late Mr. A. M. Stephen, long a resident among the Hopi people, becoming an assistant in the work. A large collection of objects gathered here by Dr. Fewkes, including a number of phono-

graphic records of Hopi singing, were added to the previous contents of the Hemenway Room at the Peabody Museum. The songs were studied by Mr. Gilman and form the subject of the present volume. In the winter of 1892 and 1893 Mrs. Hemenway commissioned Dr. Fewkes to take to Madrid a representative collection of objects from the Hopi Pueblos for exhibition at the Exposicion Historico-Americana held on the occasion of the 400th anniversary of the discovery of America. The musical results of the Expedition were of great interest to Mrs. Hemenway, who in 1893 commissioned Mr. Gilman to make a collection of phonographic records of exotic music at the Columbian Exposition in Chicago. A number of cylinders were inscribed with vocal and instrumental performances by Javanese, Samoans, Syrians, and Kwakiutl Indians, and have since been deposited with the collections from the Pueblos at the Peabody Museum.

The field work of the Expedition came to an end at Mrs. Hemenway's death in March, 1894. The following publications record its results:—

1889. The Inca Bone and Kindred Formations among the Ancient Arizonians; based on studies of skeletons found in the Rio Salado, and given by Mrs. Hemenway to the Army Medical Museum. Washington Matthews, Surgeon U. S. A.

American Anthropologist, Oct. 1, 1889, pp. 337–345, illustrations.

1890. Preliminary Note on the Origin, Working Hypothesis, and Primary Researches of the Hemenway Southwestern Archæological Expedition. Frank H. Cushing.

Congrés Internationale des Américanistes. Berlin, 1888. Compte Rendu de la 7me Session. Berlin, 1890, pp. 151–194.

On an Anatomical Characteristic of the Hyoid Bone of Pre-Columbian Pueblo Indians of Arizona, U. S. A. J. L. Wortman and Herman F. C. ten Kate. Ibid., pp. 263–270.

The Historical Archives of the Hemenway Southwestern Archæological Expedition. Adolf F. Bandelier. Ibid., pp. 450–459.

The Use of the Phonograph in the Study of the Language of the American Indians. J. Walter Fewkes.

American Naturalist, May, 1890, pp. 495, 496.

A Contribution to Passamaquoddy Folk-Lore. J. Walter Fewkes.

Journal of American Folk-Lore, Dec., 1890, pp. 257–280. A preliminary account appeared in "Science," May 2, 1890.

On the Use of the Phonograph among the Zuñi Indians. J. Walter Fewkes.

American Naturalist, July, 1890, pp. 687–691.

Additional Studies of Zuñi Songs and Rituals with the Phonograph. J. Walter Fewkes.

American Naturalist, Nov., 1890, pp. 1094–1098.

Human Bones of the Hemenway Collection in the U. S. Army Medical Museum. Washington Matthews, Surgeon U. S. A., Dr. J. L. Wortman, and Dr. John S. Billings.

Memoirs of the National Academy of Sciences. Vol. VI. Washington, 1890, pp. 165–286, with 59 plates.

Contributions to the History of the Southwestern Portion of the United States. By Adolph F. Bandelier.

Papers of the Archæological Institute of America. American Series, V. Cambridge, 1890, 206 pp., with map.

This volume contains part of the result of Mrs. Hemenway's commission to Dr. Bandelier and was published by the Expedition under the auspices of the Institute.

A Study of Some Summer Ceremonials of the Zuñi and Moki. J. Walter Fewkes.

Bulletin of Essex Institute, July, 1890, pp. 89–113.

1891. Some Games of the Zuñi. John G. Owens.

Popular Science Monthly, May, 1891, 10 pp., illus.

Suggestions as to the Meaning of the Moki Snake Dance. J. Walter Fewkes.

Journal of American Folk-Lore, June, 1891, pp. 129–138.

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1. A Few Summer Ceremonials at the Zuñi Pueblo. J. Walter Fewkes. Pp. 1–61.
2. Zuñi Melodies. Benjamin Ives Gilman. Pp. 65–91.

3. Reconnaissance of Ruins in or near the Zuñi Reservation. J. Walter Fewkes. Pp. 95–132.

1892. A Few Tusayan Pictographs. J. Walter Fewkes.
American Anthropologist, Jan., 1892, pp. 9–26, with plates.

The La-la-kon-ti; A Tusayan Dance. J. Walter Fewkes.
American Anthropologist, April, 1892, pp. 105–129, with plates.

The Mam-zrau-tu. J. Walter Fewkes and A. M. Stephen.
American Anthropologist, July, 1892, pp. 217–245, with plates.

The Na-ac-nai-ya: a Tusayan Initiation Ceremony. J. Walter Fewkes. Observations by A. M. Stephen.
Journal of American Folk-Lore, July, 1892, pp. 189–217.

The Ceremonial Circuit among the Village Indians of Northeastern Arizona. J. Walter Fewkes. Observations made jointly with A. M. Stephen and J. G. Owens.
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2. Natal Ceremonies of the Hopi Indians. John G. Owens. Pp. 163–175.
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American Anthropologist, July, 1893, pp. 323–330.

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American Anthropologist, July, 1893, pp. 285–306, with plates.

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Journal of American Folk-Lore, Oct., 1893, pp. 269–282.

Ancient Villages of Arizona. J. Walter Fewkes.
Boston Commonwealth, June 10, 1893.

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1. An Outline of the Documentary History of the Zuñi Tribe. Adolph F. Bandelier. Pp. 1–115.
2. Somatological Observations on the Indians of the South West. H. F. C. ten Kate. Pp. 119–144.

The Song of the Ancient People. Edna Dean Proctor: with an introduction by Professor John Fiske and a Commentary by Frank H. Cushing. Boston, 1893, 69 pp., with 11 aquatints by Julian Scott.

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15th Annual Report of the Bureau of Ethnology, pp. 251–312.

1894. On Certain Personages who appear in a Tusayan Ceremony. J. Walter Fewkes.
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The Kinship of a Tanoan Speaking Community in Tusayan. J. Walter Fewkes.
American Anthropologist, April, 1894, pp. 162–167.

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American Anthropologist, Oct., 1894, pp. 394–417.

Dolls of the Tusayan Indians. J. Walter Fewkes.
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Journal of American Folk-Lore, Oct., 1894, pp. 265–287.

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Comparison of Sia and Tusayan Snake Ceremonies. J. Walter Fewkes. Based in part on material collected while connected with the Hemenway Southwestern Expedition.

American Anthropologist, April, 1895, pp. 118–141.

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1. Hopi Songs. Benjamin Ives Gilman. Pp. 1–226.
2. The Hemenway Southwestern Expedition. Benjamin Ives Gilman and Katharine H. Stone. Pp. 227–235.

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